REMARKS

Applicants respectfully request reconsideration of the present application in view of the reasons that follow.

No claims are currently being amended. Claims 1-16 remain pending in this application.

Allowable subject matter

Applicants appreciate the indication that claims 9-16 are allowed, and that claim 6 contains allowable subject matter.

Rejections under 35 U.S.C. §§ 102 and 103

Claims 4-5 stand rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 5,084,816 to Boese ("Boese"). Claims 1-3 and 8 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Boese in view of U.S. Patent No. 5,898,667 to Longfield ("Longfield"). Claim 7 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Boese in view of U.S. Patent No. 6,731,649 to Silverman ("Silverman"). Applicants respectfully traverse these rejections for at least the following reasons.

Claim 1 recites "listening to point code status messages originating from distant point codes forwarded on said link, wherein the point codes are identified by point code numbers, and wherein an alignment request is issued on said link for a given combination of <u>MTP Level 1 parameter values</u>, and if no response is received on said link, automatically changing the combination of parameter values and reissuing a further alignment request until a message originating from a distant point code is received." Boese does not disclose or suggest at least this feature of claim 1.

Boese discloses that when a node is fully operational and ready to be brought into service, the link connecting the node to the remainder of the network undergoes alignment by an LSSU message with values toggling between "out of alignment" and "out of service" (col.

WASH_1708312.1

18, lines 7-12). During a signal link test an MSU is sent containing a routing label (col. 18, lines 21-31).

Boese, however, does not disclose as recited in claim 1, "listening to point code status messages originating from distant point codes forwarded on said link, wherein the point codes are identified by point code numbers, and wherein an alignment request is issued on said link for a given combination of <u>MTP Level 1 parameter values</u>, and if no response is received on said link, automatically changing the combination of parameter values and reissuing a further alignment request until a message originating from a distant point code is received." The status values of "out of alignment" and "out of service" (as well as those of "processor failure" and "signaling link out of service" in col. 18, lines 53-54) are <u>not</u> MTP Level 1 parameter values. Moreover, even if Boese could be interpreted as changing the routing during the alignment, the routing label is also not an MTP Level 1 parameter value. Thus, Boese does not suggest all the features of independent claim 1, and claim 1 is patentable thereover for at least this reason.

The Office Action states on page 9:

> Thus, examiner asserts that link status of alignment bit stream, time intervals, and/or routing label values as "MTP-1 parameter values" since they represent MTP level 1 functional characteristics of transmission channel and signaling link and a specific transmission method.

Applicants respectfully disagree that any of link status, time intervals, or routing labels are MTP Level 1 parameters, as would be recognized by one skilled in the art. While claims are interpreted in a broad manner during prosecution, such interpretation must still be from the viewpoint of one skilled in the art. In the present case, as recognized by one skilled in the art, (1) the link status is a parameter used between MTP Level 2 peers through LSSU messages to exchange link status information; (2) time intervals are parameters used by MTP Level 2 and Level 3 layers; and (3) a routing label is a parameter used between MTP Level 3 peers through MSU messages. For example, for an explanation of routing labels, see ITU-T Recommendation Q. 700, section 5.1 (attached as Exhibit 1), and for an explanation of link status, see ITU-T Recommendation Q. 703, section 11.1 (attached as Exhibit 2).

Longfield and Silverman were cited for other features of the claims, and fail to cure the deficiencies of Boese.

Independent claim 4 recites "issuing a MTP Level 2 alignment request on said link for a given combination of said MTP Level 1 parameter values, when no response is received on said link, changing said combination of parameter values, and repeating said step of issuing an alignment request; and when a response is received on said link, setting said parameter values according to the parameter values of said combination", and thus is patentable for reasons analogous to claim 1.

Independent claim 8 recites "proceeding with MTP Level 2 alignment of said link by issuing an alignment request on said link for a given combination of MTP Level 1 parameter values, and if no response is received on said link, automatically changing the combination of parameter values, and issuing a further alignment request until a signalling link test message is received on said link", and thus is patentable for reasons analogous to claim 1.

The dependent claims are patentable for at least the same reasons as their respective independent claims, as well as for further patentable features recited therein.

Applicants believe that the present application is now in condition for allowance. Favorable reconsideration of the application as amended is respectfully requested.

The Examiner is invited to contact the undersigned by telephone if it is felt that a telephone interview would advance the prosecution of the present application.

Respectfully submitted,

Date: November 1, 2006

By [signature]

HEWLETT-PACKARD COMPANY
Customer No.: 022879

William T. Ellis
Attorney for Applicant
Registration No. 26,874

Thomas G. Bilodeau
Attorney for Applicant
Registration No. 43,438

INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Q.700

(03/93)

SPECIFICATIONS OF SIGNALLING SYSTEM No. 7

INTRODUCTION TO CCITT SIGNALLING SYSTEM No. 7

ITU-T Recommendation Q.700

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation Q.700 was revised by the ITU-T Study Group XI (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

CONTENTS

Recommendation Q.700

INTRODUCTION TO CCITT SIGNALLING SYSTEM No. 7

(Melbourne 1988; modified at Helsinki 1993)

1 General

This Recommendation provides an overview of the Signalling System by describing the various functional elements of CCITT Signalling System No. 7 (SS No. 7) and the relationship between these functional elements. This Recommendation provides a general description of functions and capabilities of the Message Transfer Part (MTP), Signalling Connection Control Part (SCCP), Telephone User Part, ISDN User Part (ISUP), Transaction Capabilities (TC), and the Operations, Maintenance and Administration Part (OMAP) which are covered elsewhere in the Q.7xx-Series Recommendations. (This includes Recommendations Q.700 to Q.787.) However, in the case of contradiction between a particular specification and Recommendation Q.700, the particular specification shall apply.

The SS No. 7 ISDN supplementary services are described in the Q.73x-Series Recommendations.

In addition to these functions in the SS No. 7 signalling system, the Q.7xx Series Recommendations describes the SS No. 7 network structure, and also specifies the tests and measurements applicable to SS No. 7.

This Recommendation also contains information about other aspects such as SS No. 7 architecture, flow control and general compatibility rule which are not specified in separate Recommendations, and are applicable to the overall scope of SS No. 7. Recommendation Q.1400 also contains information about architecture and compatibility.

The remainder of this Recommendation describes:

- clause 2: Signalling network concepts components and modes;
- clause 3: The functional blocks within SS No. 7 and the services provided by them;
- clause 4: SS No. 7 protocol layering and its relationship to OSI modelling;
- clause 5: Node, application entity and user part addressing;
- clause 6: Operations, administration and maintenance aspects of SS No. 7;
- clause 7: Performance aspects of the functional blocks within SS No. 7;
- clause 8: Flow control for both the signalling network and within nodes;
- clause 9: Rules for evolving SS No. 7 protocols while preserving compatibility with earlier versions;
- clause 10: A cross-reference to a glossary of terms.

1.1 Objectives and fields of application

The overall objective of SS No. 7 is to provide an internationally standardized general purpose common channel signalling (CCS) system:

- optimized for operation in digital telecommunications networks in conjunction with stored program controlled exchanges;
- that can meet present and future requirements of information transfer for inter-processor transactions within telecommunications networks for call control, remote control, and management and maintenance signalling;
- that provides a reliable means for transfer of information in correct sequence and without loss or duplication.

The signalling system meets requirements of call control signalling for telecommunication services such as the telephone, ISDN and circuit switched data transmission services. It can also be used as a reliable transport system for other types of information transfer between exchanges and specialized centres in telecommunications networks (e.g. for

management and maintenance purposes). The system is thus applicable for multipurpose uses in networks that are dedicated for particular services and in multiservices networks. The signalling system is intended to be applicable in international and national networks.

The scope of SS No. 7 encompasses both circuit related and non-circuit related signalling.

Examples of applications supported by SS No. 7 are:

- PSTN;
- ISDN;
- Interaction with Network Databases, Service Control Points for service control;
- Mobiles (Public Land Mobile Network);
- Operations Administration and Maintenance of Networks.

The signalling system is optimized for operation over 64 kbit/s digital channels. It is also suitable for operation over analogue channels and at lower speeds. The system is suitable for use on point-to-point terrestrial and satellite links. It does not include the special features required for use in point-to-multipoint operation but can, if required, be extended to cover such an application.

1.2 General characteristics

Common channel signalling is a signalling method in which a single channel conveys, by means of labelled messages, signalling information relating to, for example, a multiplicity of circuits, or other information such as that used for network management. Common channel signalling can be regarded as a form of data communication that is specialized for various types of signalling and information transfer between processors in telecommunications networks.

The signalling system uses signalling links for transfer of signalling messages between exchanges or other nodes in the telecommunication network served by the system. Arrangements are provided to ensure reliable transfer of signalling information in the presence of transmission disturbances or network failures. These include error detection and correction on each signalling link. The system is normally applied with redundancy of signalling links and it includes functions for automatic diversion of signalling traffic to alternative paths in case of link failures. The capacity and reliability for signalling may thus be dimensioned by provision of a multiplicity of signalling links according to the requirements of each application.

1.3 Components of SS No. 7

SS No. 7 consists of a number of components or functions which are defined in the Q.7xx-Series Recommendations.

SS No. 7 function	*Recommendations*
Message Transfer Part (MTP)	Q.701-Q.704, Q.706, Q.707
Telephone User Part (TUP) (including some supplementary services)	Q.721-Q.725
Supplementary services	Q.73x Series
Data User Part (DUP)	Q.741 (see Note)
ISDN User Part (ISUP)	Q.761-Q.764, Q.766
Signalling Connection Control Part (SCCP)	Q.711-Q.714, Q.716
Transaction Capabilities (TC)	Q.771-Q.775
Operations Maintenance and Administration Part (OMAP)	Q.750-Q.755

NOTE – Functions of the DUP are fully specified in Recommendation X.61.

Other Q.7xx-Series Recommendations which describe other aspects of the signalling system which are not part of the SS No. 7 signalling interfaces are:

Title	*Recommendations*
Signalling Network Structure	Q.705
Numbering of International Signalling Point Codes	Q.708
Hypothetical signalling reference connection	Q.709
PABX application	Q.710
SS No. 7 Test Specification (General)	Q.780
MTP Level 2 Test Specification	Q.781
MTP Level 3 Test Specification	Q.782
TUP Test Specification	Q.783
ISUP Test Specification	Q.784
ISUP Supplementary Service Test Specification	Q.785
SCCP Test Specification	Q.786
TCAP Test Specification	Q.787

Clause 3 describes the relationship between these components.

1.4 Description techniques in the Q.7xx-Series Recommendations

The SS No. 7 Recommendation Series defines the signalling system using prose description which is complemented by SDL diagrams and state transition diagrams. Should any conflict arise between the text and the SDL definition, the textual description is taken as definitive.

Message sequence charts or arrow diagrams are used to illustrate examples of signalling procedures, but are not considered definitive.

Data description are increasingly using ASN.1 method of description.

2 SS No. 7 signalling network

2.1 Basic concepts

A telecommunications network served by common channel signalling is composed of a number of switching and processing nodes interconnected by transmission links. To communicate using SS No. 7, each of these nodes requires to implement the necessary "within node" features of SS No. 7 making that node a signalling point within the SS No. 7 network. In addition, there will be a need to interconnect these signalling points such that SS No. 7 signalling information (data) may be conveyed between them. These data links are the signalling links of SS No. 7 signalling network.

The combination of signalling points and their interconnecting signalling links form the SS No. 7 signalling network.

2.2 Signalling network components

2.2.1 Signalling points

In specific cases there may be a need to partition the common channel signalling functions at such a (physical) node into logically separate entities from a signalling network point of view; i.e. a given (physical) node may be defined as more than one signalling point. One example is an exchange at the boundary between international and national signalling networks.

Any two signalling points, for which the possibility of communication between their corresponding User Part function exists, are said to have a signalling relation.

The corresponding concept for a given User Part is called a user signalling relation.

An example is when two telephone exchanges are directly connected by a bundle of speech circuits. The exchange of telephone signalling relating to these circuits then constitutes a user signalling relation between the Telephone User Part functions in those exchanges in their role as signalling points.

Another example is when administration of customer and routing data in a telephone exchange is remotely controlled from an operation and maintenance centre by means of communication through a common channel signalling system.

Examples of nodes in a signalling network that constitutes signalling points are:

- exchanges (switching centres);
- service control points;
- signalling transfer points;
- operation, administration and maintenance centres.

All signalling points in a SS No. 7 network are identified by a unique code known as a point code (Recommendation Q.704 refers).

2.2.2 Signalling links

The common channel signalling system uses signalling links to convey the signalling messages between two signalling points. A number of signalling links that directly interconnect two signalling points which are used as a module constitute a signalling link-set. Although a link set typically includes all parallel signalling links, it is possible to use more than one link set in parallel between two signalling points. A group of links within a link set that have identical characteristics (e.g. the same data link bearer rate) is called a link group.

Two signalling points that are directly interconnected by a signalling link are, from a signalling network structure point of view, referred to as adjacent signalling points. Correspondingly, two signalling points that are not directly interconnected are non-adjacent signalling points.

2.2.3 Signalling modes

The term "signalling mode" refers to the association between the path taken by a signalling message and the signalling relation to which the message refers.

In the associated mode of signalling, the messages relating to a particular signalling relation between two adjacent points are conveyed over a link set, directly interconnecting those signalling points.

In the non-associated mode of signalling, the messages relating to a particular signalling relation are conveyed over two or more linksets in tandem passing through one or more signalling points other than those which are the origin and the destination of the messages.

The quasi-associated mode of signalling is a limited case of the non-associated mode where the path taken by the message through the signalling network is pre-determined and, at a given point in time, fixed.

SS No. 7 is specified for use in the associated and quasi-associated modes. The Message Transfer Part does not include features to avoid out-of-sequence arrival of messages or other problems that would typically arise in a fully non-associated mode of signalling with dynamic message routing.

Examples of signalling modes are illustrated in Figure 1.

2.3 Signalling point modes

A signalling point at which a message is generated, i.e. the location of the source User Part function, is the originating point of that message.

A signalling point to which a message is destined, i.e. the location of the receiving User Part function, is the destination point of that message.

For a particular signalling relation, the two signalling points thus function as originating and destination points for the messages exchanged in the two directions between them.

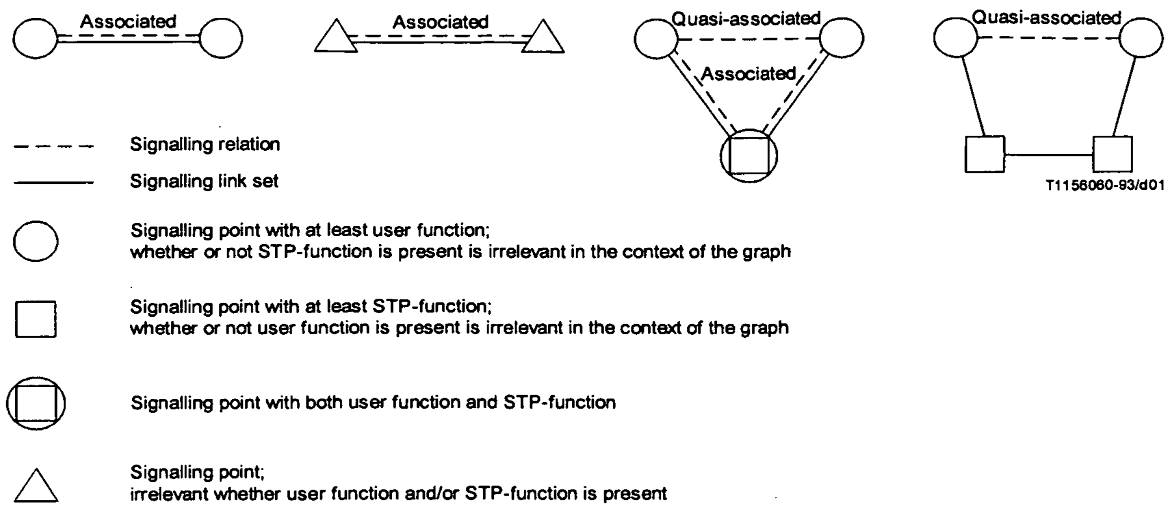


FIGURE 1/Q.700

Example of associated and quasi-associated signalling modes and definition of signalling network graph symbols

A signalling point at which a message is received on one signalling link and is transferred to another link, i.e. neither the location of the source nor the receiving User Part function, is a Signal Transfer Point (STP).

In the quasi-associated mode, the function of a signalling transfer point is typically located in a few signalling points which may be dedicated to this function, or may combine this function with some other (e.g. switching) function. A signalling point serving as a signalling transfer point functions as an originating and destination point for the messages generated and received by the level 3 function of the MTP also in cases when no user functions are present.

2.4 Signalling routes

The pre-determined path, consisting of a succession of signalling points/signalling transfer points and the interconnecting signalling links, that a message takes through the signalling network between the origination point and the destination point is the signalling route for that signalling relation.

All the signalling routes that may be used between an originating point and a destination point by a message traversing the signalling network is the signalling route set for that signalling relation.

2.5 Signalling network structure

The signalling system may be used with different types of signalling network structures. The choice between different types of signalling network structures may be influenced by factors such as the structure of the telecommunication network to be served by the signalling system and administrative aspects.

In the case when the provision of the signalling system is planned purely on a per signalling relation basis, the likely result is a signalling network largely based on associated signalling, typically supplemented by a limited degree of quasi-associated signalling for low volume signalling relations. The structure of such a signalling network is mainly determined by the patterns of the signalling relations.

Another approach is to consider the signalling network as a common resource that should be planned according to the total needs for common channel signalling. The high capacity of digital signalling links in combination with the needs for redundancy for reliability then typically leads to a signalling network based on a high degree of quasi-associated signalling with some provision for associated signalling for high volume signalling relations. The latter approach to signalling network planning is more likely to allow exploitation of the potential of common channel signalling to support network features that require communication for purposes other than the switching of connections.

The worldwide signalling network is structured into two functionally independent levels, namely the international and national levels. This structure makes possible a clear division of responsibility for signalling network management and allows numbering plans of signalling points of the international network and the different national networks to be independent of one another.

Further considerations about the structure of the signalling network are given in Recommendation Q.705, and the impact on the message transfer part in Recommendation Q.701.

3 SS No. 7 functional blocks

3.1 Basic functional division

The SS No. 7 comprises the following functional blocks:

- Message Transfer Part (MTP)
- Telephone User Part (TUP)
- ISDN User Part (ISUP)
- Signalling Connection Control Part (SCCP)
- Transaction Capabilities (TC)
- Application-Entity (AE) (see Note)
- Application-Service-Elements (ASEs) (see Note)

NOTE – The glossary shows these as hyphenated terms but the usual convention used in this Recommendation will be unhyphenated.

The fundamental principle of the signalling system structure is the division of functions into a common Message Transfer Part (MTP) on one hand, and separate User Parts for different users on the other. This is illustrated in Figure 2.

The overall function of the Message Transfer Part is to serve as a transport system providing reliable transfer of signalling messages between the locations of communicating user functions.

User functions in SS No. 7 MTP terms are:

- the ISDN User Part (ISUP)
- the Telephone User Part (TUP)
- the Signalling Connection Control Part (SCCP)
- the Data User Part (DUP)

The term "User" in this context refers to any functional entity that utilises the transport capability provided by the Message Transfer Part.

A User Part comprises those functions of, or related to, a particular type of user that are part of the common channel signalling system, typically because those functions need to be specified in a signalling context.

The SCCP also has Users. These are:

- the ISDN User Part (ISUP)
- Transaction Capabilities (TC)
- Operations Maintenance and Administration Part (OMAP)

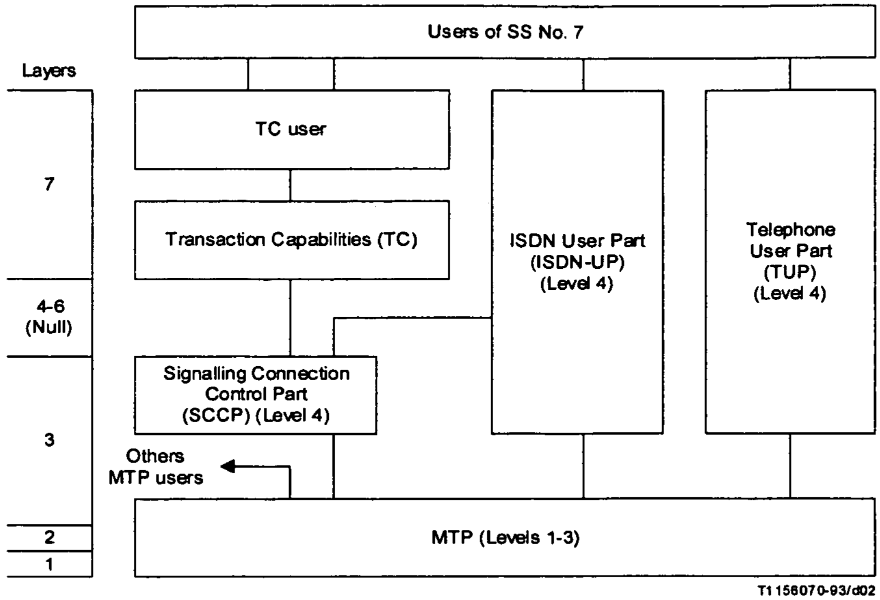


FIGURE 2/Q.700
Architecture of SS No. 7

3.2 SS No. 7 architecture

3.2.1 General

From the perspective of an end user, the service provided by a telecommunications network may be regarded as a Network Layer service. However, from a signalling network perspective, the service may be provided at a different layer/level.

Figure 2 shows the Architecture of SS No. 7 and illustrates the functional relationship between the various functional blocks of the SS No. 7 and between the SS No. 7 levels and the OSI Reference Model Layers. This level/layer relationship is described in the following subclauses.

The initial specification of SS No. 7 was based on circuit-related telephony control requirements. To meet these requirements, SS No. 7 was specified in four functional levels, the Message Transfer Part comprising levels 1-3, and the User Parts as level 4.

Figure 3 shows the Functional Levels of SS No. 7. As new requirements have emerged, e.g. for non-circuit related information transfer, SS No. 7 has also evolved to meet these new requirements. There has been a need to align certain elements in SS No. 7 to the OSI 7 Layer Reference Model (see 4.2).

3.2.2 Message Transfer Part (MTP) levels 1-3

An overview of the MTP is given in Recommendation Q.701. The MTP is defined in Recommendations Q.701-Q.704, Q.706 and Q.707.

3.2.2.1 Signalling data link functions (level 1)

Level 1 defines the physical, electrical and functional characteristics of a signalling data link and the means to access it. The level 1 function provides a bearer for a signalling link.

The detailed requirements for signalling data links are specified in Recommendation Q.702.

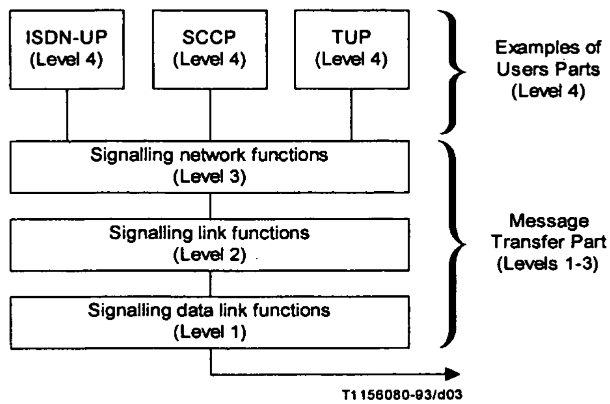


FIGURE 3/Q.700
SS No. 7 functional levels

3.2.2.2 Signalling link functions (level 2)

Level 2 defines the functions and procedures for and relating to the transfer of signalling messages over one individual signalling data link. The level 2 functions together with a level 1 signalling data link as a bearer, and provides a signalling link for reliable transfer of signalling messages between two points.

The detailed requirements for signalling functions are given in Recommendation Q.703.

3.2.2.3 Signalling network functions (level 3)

Level 3 in principle defines those transport functions and procedures that are common to and independent of the operation of individual signalling links. These functions fall into two major categories:

a) *Signalling message handling functions* – These transfer the message to the proper signalling link or User Part.

b) *Signalling network management functions* – These control the current message routing and configuration of the signalling network facilities and in the case of signalling network failures, control the reconfigurations and other actions to preserve or restore the normal message transfer capability.

The detailed requirements for signalling network functions are given in Recommendation Q.704.

3.2.3 Level 4: MTP User functions

Level 4 consists of the different User Parts. Each User Part defines the functions and procedures of the signalling system that are particular to a certain type of user of the system. The following entities are defined as User Parts in SS No. 7.

3.2.3.1 Signalling Connection Control Part (SCCP)

The SCCP is defined in Recommendations Q.711-Q.716. The SCCP provides additional functions to the Message Transfer Part to provide connectionless and connection-oriented network services to transfer circuit-related, and non-circuit-related signalling information.

The SCCP provides the means to

- control logical signalling connections in a SS 7 network;
- transfer Signalling Data Units across the SS 7 network with or without the use of logical signalling connections.

SCCP provides a routing function which allows signalling messages to be routed to a signalling point based on, for example, dialled digits. This capability involves a translation function which translates the global title (e.g. dialled digits) into a signalling point code and a sub-system number.

SCCP also provides a management function, which controls the availability of the "sub-systems", and broadcasts this information to other nodes in the network which have a need to know the status of the "sub-system". An SCCP sub-system is an SCCP User.

3.2.3.2 Telephone User Part (TUP)

The SS No. 7 Telephone User Part is defined in Recommendations Q.721-725. The TUP Recommendations define the international telephone call control signalling functions for use over SS No. 7.

3.2.3.3 Data User Part (DUP)

The Data User Part is referenced in Recommendation Q.741, and the functionality fully defined in Recommendation X.61. It defines the protocol to control interexchange circuits used on data calls, and data call facility registration and cancellation.

3.2.3.4 ISDN User Part (ISUP)

The ISDN User Part is defined in Recommendations Q.761-Q.764 and Q.766. This Recommendation Series deals with the basic services only.

The ISUP encompasses signalling functions required to provide switched services and user facilities for voice and non-voice applications in the ISDN.

The ISUP is also suited for application in dedicated telephone and circuit-switched data networks and in analogue, and mixed analogue/digital networks.

The ISUP has an interface to the SCCP (which is also a level 4 User Part) to allow the ISUP to use the SCCP for end-to-end signalling.

Supplementary Services handled by the SS No. 7 ISDN application are described in the Q.730-Series Recommendations. These supplementary services embody ISUP signalling messages and procedures. In some cases these services may include an application protocol which uses TC and SCCP.

3.2.3.5 Transaction Capabilities

Transaction Capabilities are defined in Recommendations Q.771-Q.775.

TC provides the means to establish non-circuit-related communication between two nodes in the signalling network.

3.2.3.6 Applications

Applications are modelled in layer 7. They are the process which provide the end user of the telephone or ISDN network with the basic and supplementary telecommunication services. They comprise the users of TC.

For details of the architecture of applications, see 3/Q.1400.

4 OSI layering and SS No. 7

4.1 OSI Layering

The purpose of the Reference Model of Open Systems Interconnection for CCITT Applications (see Recommendation X.200) is to provide a well-defined structure for modelling the interconnection and exchange of information between users in a communications system. This approach allows standardized procedures to be defined not only to provide an open systems interconnection between users over a single network, but also to permit interworking between networks to allow communication between users over several networks in tandem.

The approach taken in the OSI reference model is to partition the model used to describe this interconnection and exchange information between users in a communications system into seven layers.

From the point of view of a particular layer, the lower layers provide a "transfer service" with specific features. The way in which a lower layer is realized is immaterial to the next higher layers. Correspondingly, the lower layers are not concerned with the meaning of the information coming from higher layers or the reasons for its transfer.

The characteristics of each layer are described in 3a)/Q.1400 - 3g)/Q.1400.

4.2 Relationship between SS No. 7 layering and the OSI model

Evolution of the SS No. 7 architecture since the *Red Book* (1984) increasingly has been based on the Open Systems Interconnection (OSI) reference Model (see 3). OSI considers primarily connection-oriented protocols, that is, protocols that establish a logical connection before transferring data. The Network Service Part (NSP) of SS 7 provides both connectionless and connection oriented protocols.

The OSI layer 1-3 services are provided by the SCCP together with the MTP. The combination of the MTP and the SCCP is called the NSP. Layers 1-3 comprise functions for the transportation of information from one location to another, possibly via a number of communication links in tandem. These functions provide the basis on which a communication network can be built.

There are no protocols currently used in the SS No. 7 architecture that map into layers 4-6. Protocols may be included in these layers in the future if the need for such services arises.

Transaction Capabilities (TC) are defined as a protocol which directly accesses the connectionless SCCP services.

Figure 2 shows the relationship between SCCP and TC, to the OSI 7 Layer Reference Model. Recommendation Q.1400 provides further information about this relationship.

4.3 Primitive Interfaces between SS No. 7 Functions

4.3.1 General

Interfaces between the functional elements of SS No. 7 are specified using interface primitives. Primitive interface definition does not assume any specific implementation of a service.

4.3.2 OSI service primitives

Where the functional element of SS No. 7 is modelled on the OSI 7 layer reference model, e.g. SCCP, TC, service primitives are defined in line with Recommendation X.210.

In line with Recommendation X.210, Figure 4 illustrates the relationship between the terms "service", "boundary", "service primitives", "peer protocol" and "peer entities". The term "boundary" applies to boundaries between layers, as well as to boundaries between sub-layers.

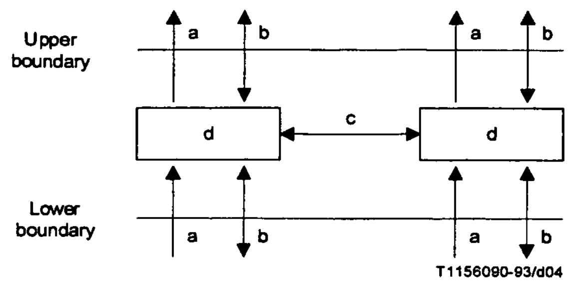
4.3.2.1 Service primitives

The use of primitives as a modelling tool does not imply any specific implementation of a service in terms of interface primitives.

Four types of service primitive are identified (see Figure 5):

- request: A primitive issued by a service user to invoke a service element.
- indication: A primitive issued by a service provider to advise that a service element has been invoked by the service user at the peer service access point or by the service provider.
- response: A primitive issued by the service user to complete at a particular service access point some service element whose invocation has been previously indicated at that service access point.
- confirmation: A primitive issued by a service provider to complete at a particular service access point some service element previously invoked by a request at that service access point.

Not all four types of service primitives have to be associated with all services.



a Service
b Service primitive
c Peer protocol
d Peer entities

FIGURE 4/Q.700
Types of service primitives

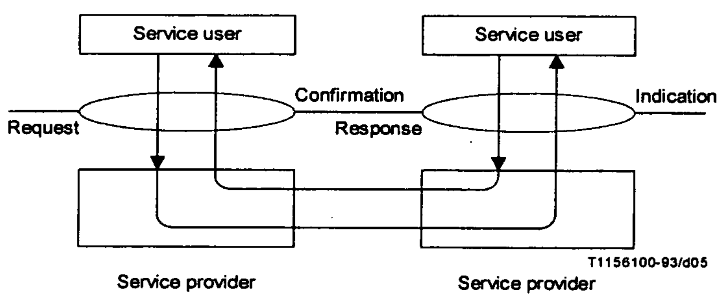


FIGURE 5/Q.700
Types of service primitives

5 Addressing

Addressing of SS No. 7 messages has to be considered on a number of levels. For example, the message transfer part uses the destination point code to route the message to the appropriate signalling point. The TUP called party address field, or ISUP called party number field, in an Initial Address Message is used to route the call to the appropriate called destination. The capabilities of the various SS No. 7 addressing mechanisms are illustrated by the signalling message structure.

5.1 Signalling message structure

A signalling message is an assembly of information, defined at level 3 or 4, pertaining to a call, management transaction, etc., that is transferred as an entity by the message transfer function.

Each message contains service information including a service indicator identifying the source User Part and possibly additional information such as an indication whether the message relates to international or national application of the User Part.

The signalling information of the message includes the actual user information, such as one or more ISDN telephone or data call control signals, management and maintenance information, etc., and information identifying the type and format of the message. It also includes a label that provides information enabling the message to be

- Routed by the level 3 functions through a signalling network to its destination. (This part of the label is known as the Routing label. This is shown in Figure 6.)
- Directed at the receiving User Part to the particular circuit, call, management or other transaction to which the message is related.

Further details are given in 5.2.

SLS	Originating Point Code	Destination Point Code

FIGURE 6/Q.700

SS No. 7 Routing Label

There are four types of label:

- type A for MTP management messages;
- type B for TUP;
- type C for ISUP (circuit related) messages;
- type D for SCCP messages.

These are shown in Figure 7.

The circuit identification code is used as a label for circuit related signalling messages, e.g. TUP or ISUP. The least significant 4 bits of this field (in the TUP) is the Signalling Link Selection (SLS) field, which is used, where appropriate, to perform load sharing (see Recommendation Q.704). In the ISUP, the SLS is a separate field to the circuit identification code.

The SS No. 7 MTP signalling messages at level 2, which carry user information, are called Message Signal Units (MSUs). Figure 8 shows the basic format of the MSU (refer also to Recommendation Q.703) and the breakdown of the MSU. The Signalling Information Field (SIF) is used to carry level 3 or level 4 messages that may be circuit-related (e.g. ISUP, TUP messages) or non-circuit-related (e.g. SCCP). Further details are given on message formats in Recommendations Q.704, Q.713, Q.723, Q.763 and Q.773.

5.2 MTP addressing

There is a two part addressing mechanism in the MTP, one part of the mechanism uses the point code which is incorporated in the routing label of every message signal unit, the other part of the mechanism makes use of the service indicator and network indicator within the service information octet.

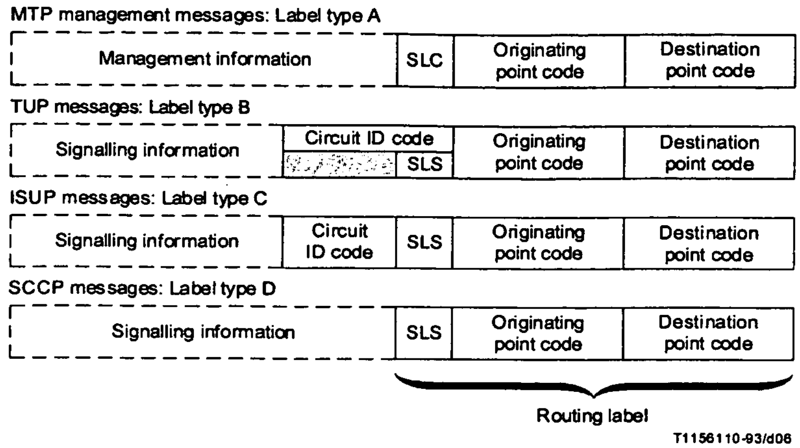


FIGURE 7/Q.700

SS No. 7 message label types

5.2.1 Point codes

Every signalling point (SP) and signalling transfer point (STP), when integrated in an SP, will be allocated its own unique point code. This is used by the MTP routing function to direct outgoing messages towards their destination in the network as indicated by the inclusion of the appropriate point code in the routing label. This point code is known as the destination point code (DPC). The routing label also contains the point code of the SP originating the message signal unit, therefore, the combination of this originating point code (OPC) and DPC will determine the signalling relation (i.e. the network points between which MTP "User" information is exchanged). The DPC is used by the receiving SP/STP discrimination function to determine whether the message is addressed to that SP or requires to be onward routed by means of the signal transfer capability of the STP.

The DPC will always be determined and inserted in the routing label by the level 4 MTP "User". This will also generally be the same for the OPC but it is possible that since the OPC might be constant it could be inserted by the MTP.

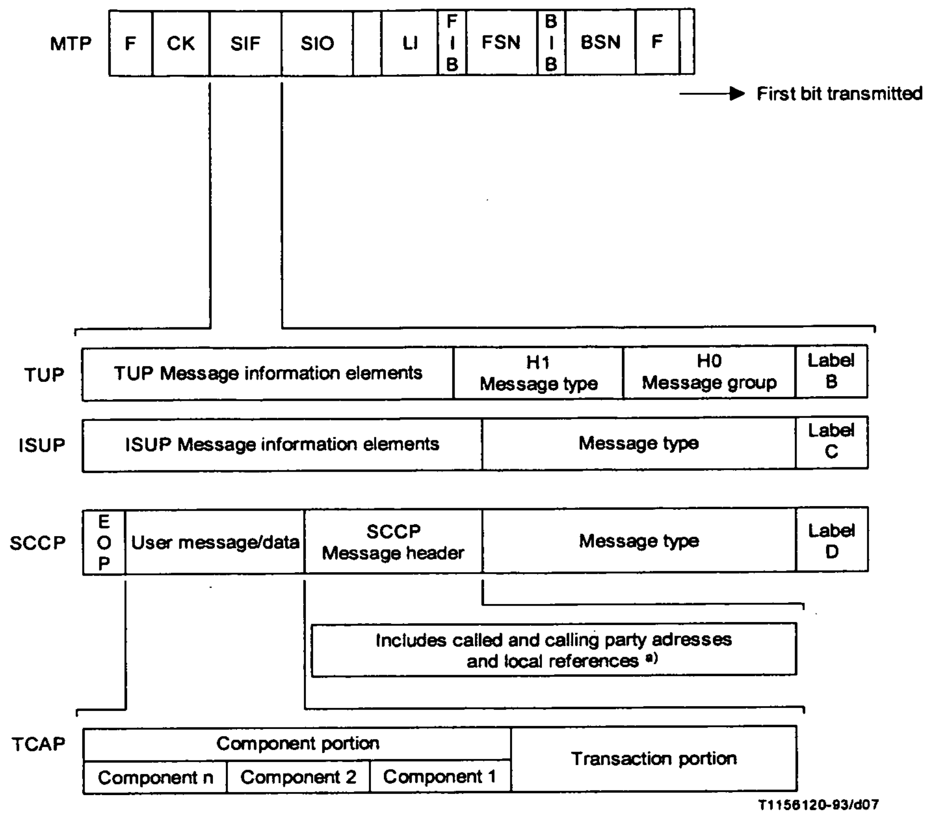
5.2.2 Service indicator and network indicator

The 4-bit service indicator (SI) and 2-bit network indicator (NI) are included in the service information octet (SIO) and are used within an SP's distribution function to determine the "User" the incoming message should be delivered to.

The SI will determine the "User", e.g. TUP, SCCP, ISUP and the NI will determine which network is concerned, e.g. international or national.

The NI will also in conjunction with the OPC/DPC determine whether a national or international signalling relation/routing is involved.

The NI, together with the standard 14-bit point code, allows for four signalling networks each with up to 16 384 point codes.



a) CO only.

BIB	Backward indicator bit
BSN	Backward sequence number
CK	Check bits
F	Flag
FIB	Forward indicator bit
FSN	Forward sequence number
LI	Length indicator
SF	Status field
SIF	Signalling information field
SIO	Service information octet

FIGURE 8/Q.700

SS No. 7 signalling message structure

5.3 SCCP addressing

Addressing within the SCCP of SS No. 7 makes use of three separate elements:

- DPC;
- Global Title (GT);
- Sub-System Number (SSN);

One, two or all of the elements may be present in the Called and Calling Party Address, the main options are:

GT DPC + SSN	When transferring SCCP messages
SSN GT SSN + GT	When receiving messages from MTP
DPC DPC + (SSN or GT or both) GT GT + SSN	When receiving messages from connectionless or connection-oriented control for SCCP routing

The form of address used will depend on the service, application and underlying network.

5.3.1 Global Title (GT)

The Global Title (GT) may comprise of dialled digits or another form of address that will not be recognized in the SS No. 7 network. Therefore, if the associated message requires to be routed over the SS No. 7 network, translation is required.

Translation of the GT will result in a DPC being produced and possibly also a new SSN and GT. A field is also included in the address indicator to identify the format of the global title.

5.3.2 Destination Point Code (DPC)

The DPC in an address requires no translation and will merely determine if the message is destined for that SP (incoming message) or requires to be routed over the SS No. 7 signalling network via the MTP. For outgoing messages this DPC should be inserted in the MTP routing label.

5.3.3 Sub-system Number (SSN)

The SSN will identify a sub-system accessed via the SCCP within a node and may be a User Part, e.g. ISUP, SCCP management or an AE via TC. TC, however, will be invisible to the SCCP.

When examination of the DPC in an incoming message has determined that the message is for that SP, examination of the SSN will identify the concerned SCCP "User". The presence of an SSN without a DPC will also indicate a message which is addressed to that SP.

The SSN field has an initial capacity of 255 codes with an extension code for future requirements.

5.4 User Part addressing

5.4.1 Telephone User Part addressing

The Telephone User Part is capable of handling E.164 (incorporating E.163) addresses in the calling and called party address information elements.

5.4.2 ISDN User Part addressing

The ISDN User Part address structure is capable of handling E.164 addresses in the calling and called number, and redirecting address information elements.

5.4.3 Signalling connection control part addresses

The signalling connection control part is capable of handling E.164 (incorporating E.163), X.121, F.69, E.210, E.211, E.212, E.213 addresses, and the mobile hybrid E.214 address in the calling and called party address information elements.

The handling of OSI NSAP addresses in SCCP is described in Recommendation Q.711 and 3.2/Q.1400.

5.5 Labelling

A variety of methods to label signalling messages is used to allow the signalling system and users of the signalling system to relate a received message to a particular call or transaction.

For circuit-related messages, (e.g. on a simple telephone call), the TUP (and the ISUP) use the circuit identification code (CIC) to label the message.

For certain ISUP procedures, call references are used to associate messages with calls.

SCCP also uses local references on connection-oriented protocols.

Transaction capabilities use transaction identities and invoke identities to associate transaction messages and components respectively.

6 Operations administration and maintenance

6.1 Management

Management within SS No. 7 is partitioned into two main areas:

- Signalling network management;
- Signalling system management.

6.1.1 Signalling network management

These are functions contained within the MTP and SCCP which, by means of automatic procedures, maintain the required signalling network performance (e.g. changeover of faulty links, forced re-routing, sub-system availability, etc.).

6.1.2 Signalling system management

This may be considered as the actions taken by the operator (or by an external automatic mechanism) such as TMN-OS via the Q3 interface to maintain the signalling system performance when problems are identified.

6.2 Maintenance and testing

Some of the maintenance, administration and management functions of the signalling system themselves use the signalling system as a data carrying mechanism.

Testing within SS No. 7 is:

- initiated automatically as a part of a signalling system management procedures (e.g. signalling route set test in MTP); or
- applied as a result of external activity, e.g. man-machine interface (MMI) or TMN.

The first form is described in the appropriate Q.7xx Recommendation dealing with MTP or SCCP, etc. The second form includes some MMI or TMN initiated procedures [initiation of MRVT (Recommendation Q.753)], and also pre-in service testing using test cases specified in Recommendations for SS No. 7 tests (Q.78x-Series).

6.2.1 Operations Maintenance and Administration Part (OMAP)

Recommendation Q.75x provides procedures and protocols related to operations, maintenance and administration.

OMAP is situated in the TMN-OS as well as in SS No. 7 SPs of all kinds, OMAP functions include measurement initiation and collection as well as initiation of tests within the SS No. 7 network like MRVT.

6.2.2 Testing

Test specifications for SS No. 7 are contained in Q.78x-Series Recommendations and cover MTP level 2, MTP level 3, TUP, ISUP, SCCP and TCAP together with an overview of testing.

6.3 SS No. 7 measurements

Recommendation Q.752 specifies the monitoring and measurements appropriate to the MTP, SCCP, ISUP and TCAP.

7 Signalling system performance

The performance requirements of SS No. 7 must take account of the performance requirements of the services that are being supported. Each functional component of SS No. 7 has its performance criteria specified in a self-contained Recommendation. An overall performance target is specified in the form of a Hypothetical Signalling Reference Connection (HSRC).

7.1 Hypothetical Signalling Reference Connection (HSRC)

The HSRC for SS No. 7 (Recommendation Q.709), identifies components that are used in a signalling relation between signalling end points, signalling points, signalling transfer points, and signalling points with SCCP relay functions, and gives the values for the signalling delays and unavailability parameters. The values used are derived from the figures contained in the individual performance Recommendations for MTP, TUP, SCCP and ISUP. Service performance Recommendations E.721 and I.352 also apply.

7.2 MTP

The MTP signalling performance requirements are specified in Recommendation Q.706. This Recommendation includes

- the parameters for route-set unavailability, MTP malfunction (loss of messages and mis-sequencing), and message transfer times;
- factors affecting performance, for example signalling traffic characteristics (e.g. message sizes, loading potential, security, etc.) and parameters related to transmission characteristics (e.g. bit rates of signalling data links, propagation delays);
- those parameters which have greatest influence on the signalling network queueing delays for example, error control, security arrangements, failures and priorities.

It should be noted that some functions may affect MTP performance.

7.3 SCCP

The SCCP signalling performance requirements are contained in Recommendation Q.716. Parameters identified are signalling connection delays (establishment, unsolicited reset, reset and release signal connection, reset and release failure probability, data message transmit delay, data message delay failure and error probability and SCCP unavailability).

It should be noted that management functions affect SCCP performance.

7.4 TUP

The TUP signalling performance requirements are contained in Recommendation Q.725. Parameters contained in this Recommendation are cross-office performance for TUP supported circuit connection control under normal and abnormal traffic loads. Also specified is the probability of failure of calls due to signalling malfunction.

7.5 ISUP

The ISUP signalling performance requirements are contained in Recommendation Q.766. Parameters contained in this Recommendation are cross-office performance for ISUP supported circuit connection control under normal and abnormal traffic loads. Also specified is the probability of failure of an ISDN call due to signalling function.

8 Flow control

SS No. 7, in common with other transport mechanisms, needs to limit the input of data when congestion onset is detected. The nature of SS No. 7 will lead to SP/STP overload congestion being spread through the signalling network if no action is taken. This will result in impaired signalling performance and message loss. In addition to signalling network congestion within a node, congestion will also require action to prevent signalling performance from deteriorating. There is thus a need for flow control within the signalling system to maintain the required signalling performance.

8.1 Signalling network flow control

This is achieved by incorporating a flow control mechanism in the MTP. On detection of congestion, MTP "Users Parts" are informed by the means of a primitive. The "User Part" should then reduce signalling traffic towards the congested part of the network. If the User is at a remote SP, the information is carried across the network in an appropriate signalling network management message.

8.2 Signalling node (congestion) flow control

In addition to network congestion, nodal congestion also requires the remedial action of flow control to prevent the signalling performance from being impaired. Nodal congestion can occur both within the MTP and the MTP "User Part".

8.2.1 MTP nodal flow control

If MTP node overload is detected similar action to that used to combat signalling network congestion is required. On detection of that overload, the "User Parts" are informed so that traffic can be reduced.

8.2.2 "User Part" flow control

As well as taking action to reduce MTP congestion, mechanisms are also required within each User Part to detect the onset of congestion and to take appropriate action.

The ISUP and TUP provide signalling procedures which aim to reduce the new calls offered to an exchange which is experiencing processor overload.

Automatic congestion control provides the means to inform adjacent exchanges of the current workload, and to request that only priority calls are offered to the exchange experiencing overload.

9 Compatibility mechanisms and rules in SS No. 7

9.1 Background

The wide scope of the signalling system requires that the total system include a large diversity of functions and that further functions can be added to cater for extended future applications. As a consequence only a subset of the total system may need to be used in an individual application.

A major characteristic of the signalling system is that it is specified with a functional structure to ensure flexibility and modularity for diverse applications within one system concept. This allows the system to be realized as a number of functional modules which could ease adaptation of the functional content of an operating SS No. 7 to the requirements of particular applications.

The CCITT specifications of the signalling system specify functions and their use for international operation of the system. Many of those functions are also required in typical national applications. Furthermore, the system to some extent includes features that are particular to national applications. The CCITT specifications thus form an internationally standardized base for a wide range of national applications of common channel signalling.

SS No. 7 is a common channel signalling system. However, as a consequence of its modularity and its intended use as a standard base for national applications the system may be applied in many forms. In general, to define the use of the system in a given national application, a selection of the CCITT specified functions must be made and the necessary additional national functions must be specified depending on the nature of the application.

SS No. 7 is an evolutionary signalling system which has undergone a number of enhancements. To allow ease of evolution it has been necessary to incorporate a number of compatibility mechanisms in various functional elements of SS No. 7, and to apply a number of compatibility rules to protocol enhancement. Detailed specification of the compatibility mechanisms in each functional element of SS No. 7 are given in the appropriate Q.7xx Recommendation.

Compatibility rules which apply to all functional elements of SS No. 7 are detailed in the following text.

9.2 Evolutionary requirements

In application protocols (e.g. ISUP, ASEs), the main evolutionary requirement is the ability to add new subscriber services, and new administration and network services to the protocol.

In the SCCP and MTP, the evolutionary requirements are different in that initial versions provide basic transport functions which are generally stable. The main enhancements have been in the management aspects of protocols.

Although the evolutionary requirements are different across the elements of SS No. 7, it is possible to incorporate certain common mechanisms in the various functional elements.

9.3 Forward and backward compatibility

Compatibility mechanisms can be considered as being either

- forward compatibility mechanisms; or
- backward compatibility rules.

Forward compatibility mechanisms are defined as a scheme to enable a version of a protocol to communicate effectively and interwork with future versions of the protocol. That is, a version of a protocol should not restrict future protocols from providing extra capabilities.

Backward compatibility rules are defined as a scheme to ensure that future versions of the protocol will be able to send protocol messages to the previous version which will be understood and fully processed by the node supporting the previous version. That is, future versions of a protocol must allow earlier versions to operate with it and not reduce the earlier versions' service level.

9.4 Compatibility rules for SS No. 7

Compatibility rules for SS No. 7 protocol evolution are contained in 9/Q.1400.

Note that the 1992 ISUP Recommendations (Q.76x-Series Recommendations) contain a special compatibility procedure. It uses an instruction indicator, which includes information about the handling of a parameter or message that is not recognized (e.g. discard, pass-on, send Confusion). It is sent with every new message or parameter. For parameters

containing new values, it is assumed that the instruction indicator for the whole parameter can be used for all values within the parameter. For existing messages, parameters and parameter values, the required action if unrecognized information is received is given in tabular form.

10 Glossary

A Glossary of terms in SS No. 7 is contained at the back of the Fascicles VI.7, VI.8 and VI.9 of the *Blue Book*.

INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Q.703

(07/96)

SERIES Q: SWITCHING AND SIGNALLING

Specifications of Signalling System No. 7 – Message transfer part

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Signalling link

ITU-T Recommendation Q.703

(Previously CCITT Recommendation)

ITU-T Q-SERIES RECOMMENDATIONS

SWITCHING AND SIGNALLING

SIGNALLING IN THE INTERNATIONAL MANUAL SERVICE	Q.1–Q.3
INTERNATIONAL AUTOMATIC AND SEMI-AUTOMATIC WORKING	Q.4–Q.59
FUNCTIONS AND INFORMATION FLOWS FOR SERVICES IN THE ISDN	Q.60–Q.99
CLAUSES APPLICABLE TO ITU-T STANDARD SYSTEMS	Q.100–Q.119
SPECIFICATION OF SIGNALLING SYSTEMS No. 4 AND No. 5	Q.120–Q.249
SPECIFICATIONS OF SIGNALLING SYSTEM No. 6	Q.250–Q.309
SPECIFICATIONS OF SIGNALLING SYSTEM R1	Q.310–Q.399
SPECIFICATIONS OF SIGNALLING SYSTEM R2	Q.400–Q.499
DIGITAL EXCHANGES	Q.500–Q.599
INTERWORKING OF SIGNALLING SYSTEMS	Q.600–Q.699
SPECIFICATIONS OF SIGNALLING SYSTEM No. 7	Q.700–Q.849
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Simplified message transfer part	Q.710
Signalling connection control part	Q.711–Q.719
Telephone user part	Q.720–Q.729
ISDN supplementary services	Q.730–Q.739
Data user part	Q.740–Q.749
Signalling System No. 7 management	Q.750–Q.759
ISDN user part	Q.760–Q.769
Transaction capabilities application part	Q.770–Q.779
Test specification	Q.780–Q.799
Q3 interface	Q.800–Q.849
DIGITAL SUBSCRIBER SIGNALLING SYSTEM No. 1	Q.850–Q.999
PUBLIC LAND MOBILE NETWORK	Q.1000–Q.1099
INTERWORKING WITH SATELLITE MOBILE SYSTEMS	Q.1100–Q.1199
INTELLIGENT NETWORK	Q.1200–Q.1999
BROADBAND ISDN	Q.2000–Q.2999

For further details, please refer to ITU-T List of Recommendations.

ITU-T RECOMMENDATION Q.703

SIGNALLING LINK

Summary

This Recommendation describes the functions and procedures for and relating to the transfer of messages over one signalling data link. Annex A has been added to support the use of data rates of 1.5 and 2.0 Mbit/s as a national option. In addition some errors in the SDL diagrams have been corrected.

Source

ITU-T Recommendation Q.703 was revised by ITU-T Study Group 11 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 9th of July 1996.

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

CONTENTS

Recommendation Q.703

SIGNALLING LINK

(Geneva 1980; modified at Helsinki, 1993, revised in 1996)

1 General

1.1 Introduction

1.1.1 This Recommendation describes the functions and procedures for and relating to the transfer of signalling messages over one signalling data link. The signalling link functions, together with a signalling data link as bearer, provide a signalling link for reliable transfer of signalling messages between two directly connected *signalling points*.

Signalling messages delivered by superior hierarchical levels are transferred over the signalling link in variable length *signal units*. The signal units include transfer control information for proper operation of the signalling link in addition to the signalling information.

1.1.2 The signalling link functions comprise:

a) signal unit delimitation;

b) signal unit alignment;

c) error detection;

d) error correction;

e) initial alignment;

f) signalling link error monitoring;

g) flow control.

All these functions are coordinated by the *link state control* (see Figure 1).

1.2 Signal unit delimitation and alignment

The beginning and end of a signal unit are indicated by a unique 8-bit pattern, called the *flag*. Measures are taken to ensure that the pattern cannot be imitated elsewhere in the unit.

Loss of alignment occurs when a bit pattern disallowed by the delimitation procedure (more than six consecutive 1 s) is received, or when a certain maximum length of signal unit is exceeded.

Loss of alignment will cause a change in the mode of operation of the *signal unit error rate monitor*.

1.3 Error detection

The error detection function is performed by means of 16 check bits provided at the end of each signal unit. The check bits are generated by the transmitting signalling link terminal by operating on the preceding bits of the signal unit following a specified algorithm. At the receiving *signalling link terminal*[1], the received check bits are operated on using specified rules which correspond to that algorithm.

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[1] A *signalling link terminal* refers to the means of performing all of the functions defined at level 2 regardless of their implementation.

If consistency is not found between the received check bits and the preceding bits of the signal unit, according to the algorithm, then the presence of errors is indicated and the signal unit is discarded.

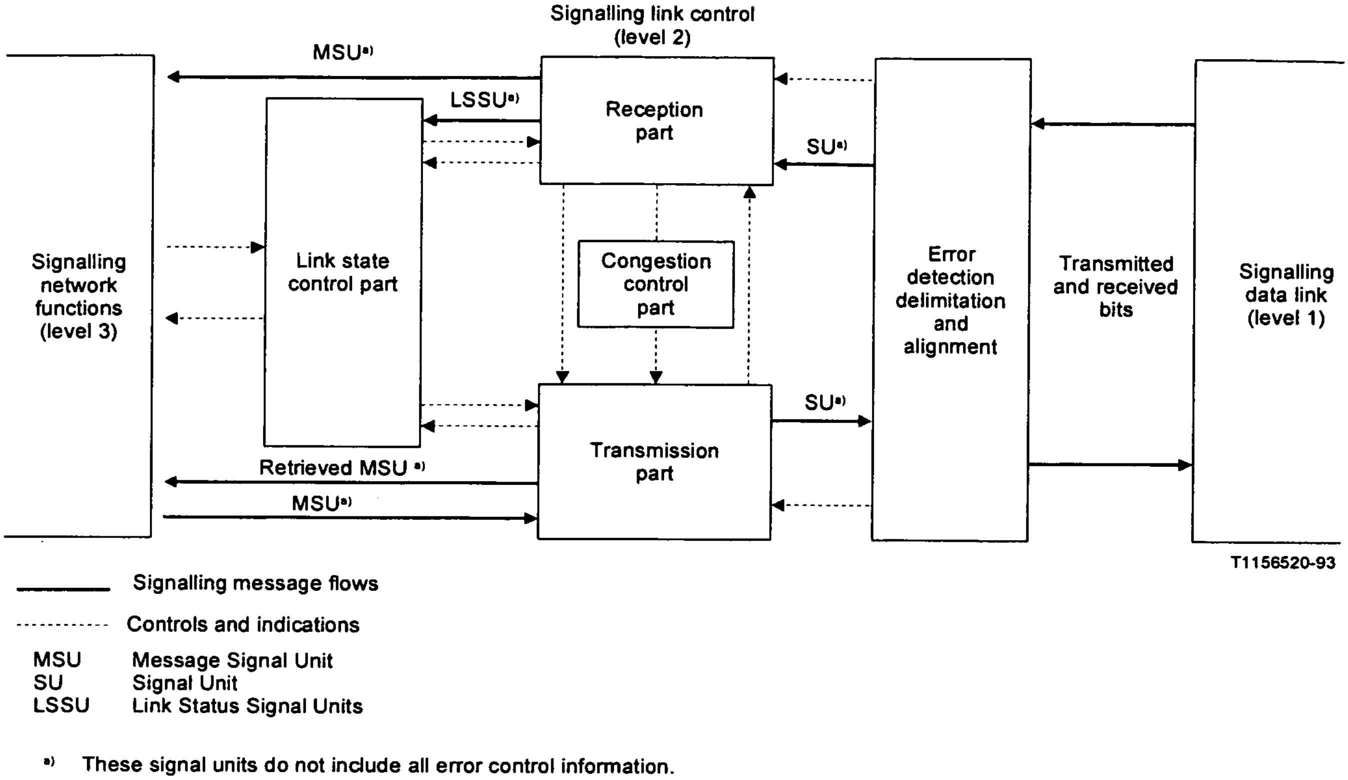


Figure 1/Q.703 – Interactions of the functional specification blocks for signalling link control

1.4 Error correction

1.4.1 Two forms of error correction are provided, the *basic method* and the *preventive cyclic retransmission method.* The following criteria should be used for determining the international fields of application for the two methods:

a) the basic method applies for signalling links using non-intercontinental terrestrial transmission means and for intercontinental signalling links where the one-way propagation delay is less than 15 ms;

b) the preventive cyclic retransmission method applies for intercontinental signalling links where the one-way propagation delay is greater than or equal to 15 ms and for all signalling links established via satellite.

In cases where one signalling link within an international link set is established via satellite, the preventive cyclic retransmission method should be used for all signalling links of that link set (combined linkset).

1.4.2 The basic method is a non-compelled, positive/negative acknowledgement, retransmission error correction system. A signal unit which has been transmitted is retained at the transmitting signalling link terminal until a positive acknowledgement for that signal unit is received. If a negative acknowledgement is received, then the transmission of new signal units is interrupted and those signal units which have been transmitted but not yet positively acknowledged starting with that

indicated by the negative acknowledgement will be retransmitted once, in the order in which they were first transmitted.

1.4.3 The preventive cyclic retransmission method is a non-compelled, positive acknowledgement, cyclic retransmission, forward error correction system. A signal unit which has been transmitted is retained at the transmitting signalling link terminal until a positive acknowledgement for that signal unit is received. During the period when there are no new signal units to be transmitted, all the signal units which have not yet been positively acknowledged are retransmitted cyclically.

The *forced retransmission procedure* is defined to ensure that forward error correction occurs in adverse conditions (e.g. high error rate and/or high traffic loading).

When a predetermined number of retained, unacknowledged signal units exists, the transmission of new signal units is interrupted and the retained signal units are retransmitted cyclically until the number of unacknowledged signal units is reduced.

1.5 Initial alignment

The initial alignment procedure is appropriate to both first time initialization (e.g. after "switch-on") and alignment in association with restoration after a link failure. The procedure is based on the compelled exchange of status information between the two *signalling points* concerned and the provision of a proving period. No other signalling link is involved in the initial alignment of any particular link, the exchange occurs only on the link to be aligned.

1.6 Signalling link error monitoring

Two signalling link error rate monitor functions are provided: one which is employed whilst a signalling link is in service and which provides one of the criteria for taking the link out of service, and one which is employed whilst a link is in the proving state of the initial alignment procedure. These are called the *signal unit error rate monitor* and the *alignment error rate monitor* respectively. The characteristics of the signal unit error rate monitor are based on a signal unit error count, incremented and decremented using the "leaky bucket" principle whilst the alignment error rate monitor is a linear count of signal unit errors. During loss of alignment, the signal unit error rate monitor error count is incremented in proportion to the period of the loss of alignment.

1.7 Link state control functions

Link state control is a function of the signalling link which provides directives to the other signalling link functions. The interfaces with link state control are shown in Figures 1 and 7. The split into the functional blocks shown in the figures is made to facilitate description of the signalling link procedures and should not be taken to imply any particular implementation.

The link state control function is shown in the overview diagram, Figure 2, and the detailed state transition diagram, Figure 8.

1.8 Flow control

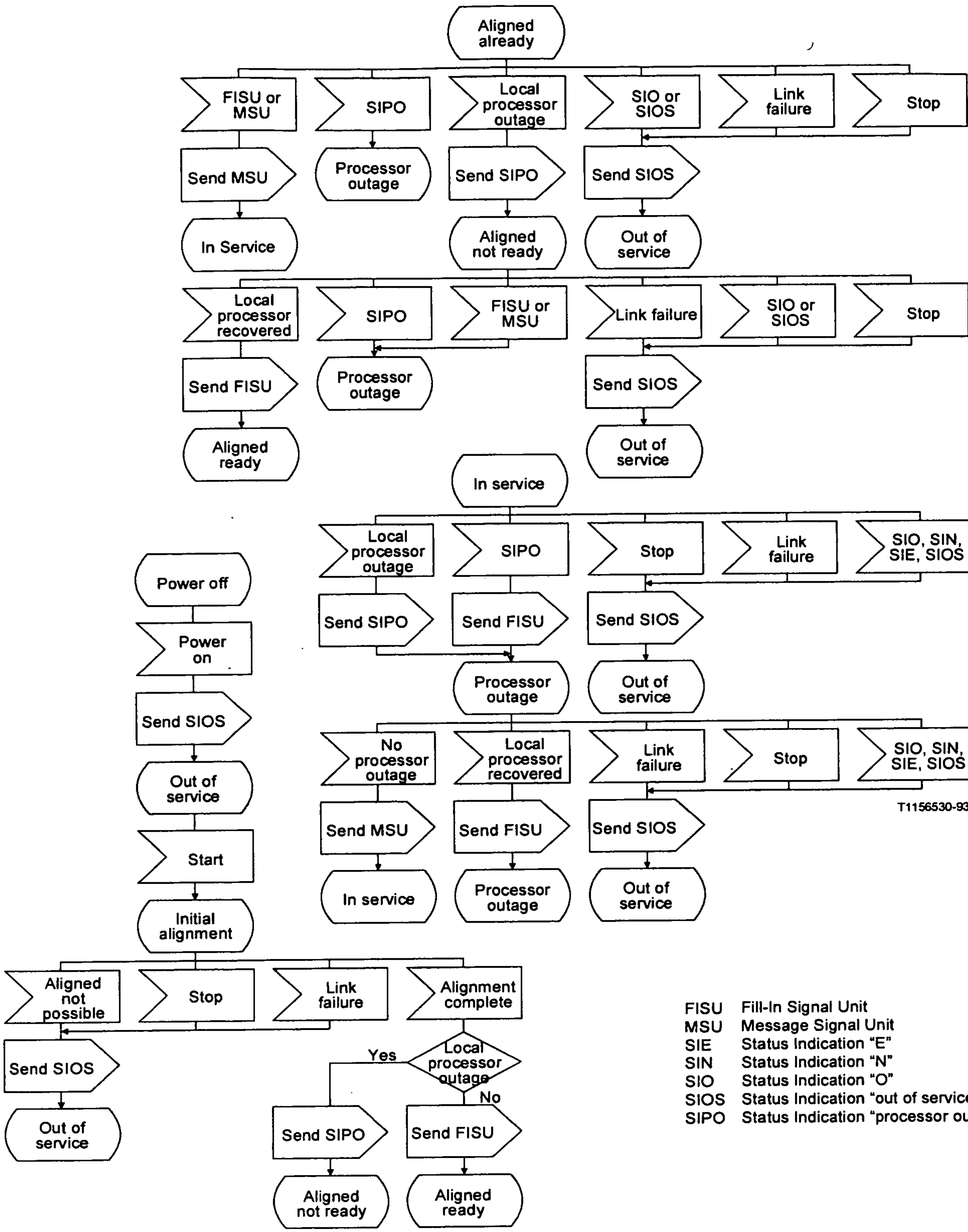
Flow control is initiated when congestion is detected at the receiving end of the signalling link. The congested receiving end of the link notifies the remote transmitting end of the condition by means of an appropriate link status signal unit and it withholds acknowledgements of all incoming message signal units. When congestion abates acknowledgements of all incoming message signal units is resumed. While congestion exists, the remote transmitting end is periodically notified of this condition. The remote transmitting end will indicate the link as failed if the congestion continues too long.

2 Basic signal unit format

2.1 General

Signalling and other information originating from a User Part is transferred over the signalling link by means of signal units.

A signal unit is constituted of a variable length *signalling information field* which carries the information generated by a *User Part* and a number of fixed length fields which carry information required for message transfer control. In the case of link status signal units, the signalling information field and the service information octet is replaced by a status field which is generated by the signalling link terminal.

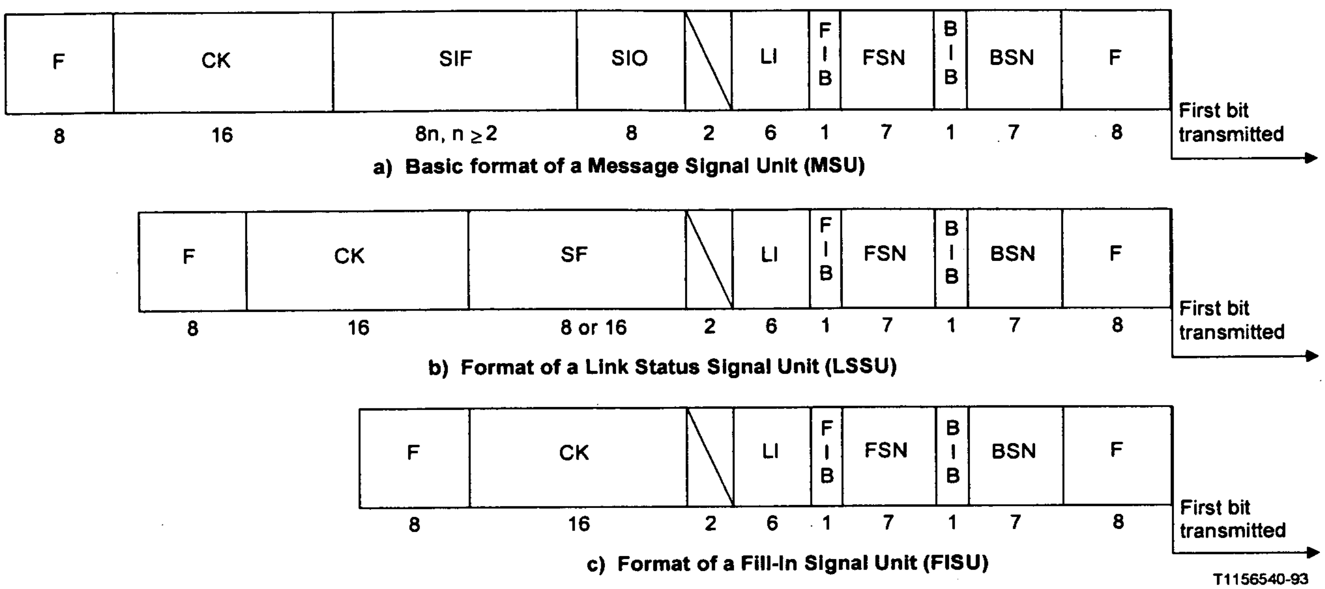


FISU Fill-In Signal Unit
MSU Message Signal Unit
SIE Status Indication "E"
SIN Status Indication "N"
SIO Status Indication "O"
SIOS Status Indication "out of service"
SIPO Status Indication "processor outage"

Figure 2/Q.703 – Overview diagram of link state control

2.2 Signal unit format

Three types of signal unit are differentiated by means of the *length indicator* contained in all signal units, i.e. message signal units, link status signal units and fill-in signal units. Message signal units are retransmitted in case of error, link status signal unit and fill-in signal units are not. The basic formats of the signal units are shown in Figure 3.



BIB	Backward Indicator Bit
BSN	Backward Sequence Number
CK	Check bits
F	Flag
FIB	Forward Indicator Bit
FSN	Forward Sequence Number
LI	Length Indicator
n	Number of octets in the SIF
SF	Status Field
SIF	Signalling Information Field
SIO	Service Information Octet

Figure 3/Q.703 – Signal unit formats

2.3 Function and codes of the signal unit fields

2.3.1 General

The message transfer control information encompasses 8 fixed length fields in the signal unit which contains information required for error control and message alignment.

2.3.2 Flag

The opening flag indicates the start of a signal unit. The opening flag of one signal unit is normally the closing flag of the preceding signal unit. The closing flag indicates the end of a signal unit. The bit pattern for the flag is 01111110.

2.3.3 Length indicator

The length indicator is used to indicate the number of octets following the length indicator octet and preceding the *check bits* and is a number in binary code in the range 0-63. The length indicator differentiates between the three types of signal units as follows:

Length indicator = 0:	Fill-in signal unit
Length indicator = 1 or 2:	Link status signal unit
Length indicator > 2:	Message signal unit

In the case that the signalling information field of a message signal unit is spanning 62 octets or more, the length indicator is set to 63.

It is mandatory that LI is set by the transmitting end to its correct value as specified above.

2.3.4 Service information octet

The *service information octet* is divided into the *service indicator* and the *subservice field*. The service indicator is used to associate signalling information with a particular user part and is present only in message signal units.

The content of the subservice field is described in 14.2.2/Q.704.

NOTE – The Message Transfer Part may handle messages for different users (i.e. messages with different service indicators) with different priorities. These priorities are for further study.

2.3.5 Sequence numbering

The *forward sequence number* is the sequence number of the signal unit in which it is carried.

The *backward sequence number* is the sequence number of a signal unit being acknowledged.

The forward sequence number and backward sequence number are numbers in binary code from a cyclic sequence ranging from 0 to 127 (see clauses 5 and 6).

2.3.6 Indicator bits

The *forward indicator bit* and *backward indicator bit* together with the forward sequence number and backward sequence number are used in the basic error control method to perform the signal unit sequence control and acknowledgement functions (see 5.2 and clause 6).

2.3.7 Check bits

Every signal unit has 16 check bits for error detection (see clause 4).

2.3.8 Signalling information field

The *signalling information field* consists of an integral number of octets, greater than or equal to 2 and less than or equal to 272.

The value 272 allows a single message signal unit to accommodate information blocks of up to 268 octets in length accompanied by a routing label.

The format and codes of the signalling information field are defined for each user part.

2.3.9 Status field

The formats and codes of the *status field* are described in clause 11.

2.3.10 Spare fields

Spare fields are coded 0, unless otherwise indicated (see Figures 3 and 6).

2.4 Order of bit transmission

Each of the fields mentioned in 2.3 will be transmitted in the order indicated in Figure 3.

Within each field or subfield the bits will be transmitted with the least significant bit first. The 16 check bits are transmitted in the order generated (see clause 4).

3 Signal unit delimitation

3.1 Flags

A signal unit includes an opening flag (see 2.2). The opening flag of a signal unit is normally considered to be the closing flag of the preceding signal unit. In certain conditions (e.g. signalling link overload) a limited number of flags may be generated between two consecutive signal units. However, a signalling link terminal always should be able to receive consecutive signal units with one or more multiple flags inserted between them.

3.2 Zero insertion and deletion

To ensure that the flag code is not imitated by any other part of the signal unit the transmitting signalling link terminal inserts a 0 after every sequence of five consecutive 1 s before the flags are attached and the signal unit is transmitted. At the receiving signalling link terminal, after flag detection and removal, each 0 which directly follows a sequence of five consecutive 1 s is deleted.

4 Acceptance procedure

4.1 Acceptance of alignment

4.1.1 A flag which is not followed immediately by another flag is considered an opening flag. Whenever an opening flag is received, the beginning of a signal unit is assumed. When the next flag (a closing flag) is received it is assumed to be the termination of the signal unit.

4.1.2 If seven or more consecutive 1 s are received, the signal unit error rate monitor or alignment error rate monitor enters the "octet counting" mode (see 4.1.4) and the next valid flag is searched for.

4.1.3 After deletion of the 0 s inserted for transparency, the received signal unit length is checked for being a multiple of 8 bits and at least 6 octets, including opening flag. If it is not, then the signal unit is discarded and the signal unit error rate monitor or alignment error rate monitor is incremented. If more than $m + 7$ octets are received before a closing flag, the "octet counting" mode is entered (see Figure 11) and the signal unit is discarded. m is the maximum length of the signalling information field (in octets) allowed on a signalling link. m takes the value 272. In the case of the basic error control method a negative acknowledgement will be sent, if required, according to the rules set out in 5.2.

4.1.4 When the "octet counting" mode is entered all the bits received after the last flag and before the next flag are discarded. The "octet counting" mode is left when the next correctly-checking signal unit is received, and this signal unit is accepted.

4.2 Error detection

The error detection function is performed by means of 16 check bits provided at the end of each signal unit.

The check bits are generated by the transmitting signalling link terminal. They are the ones complement of the sum (modulo 2) of

i) the remainder of x^k $(x^{15} + x^{14} + x^{13} + x^{12} \ldots + x^2 + x + 1)$ divided (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$, where k is the number of bits in the signal unit existing between, but not including, the final bit of the opening flag and the first bit of the check bits, excluding bits inserted for transparency; and

ii) the remainder after multiplication by x^{16} and then division (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$ of the content of the signal unit existing between, but not including, the final bit of the opening flag and the first bit of the check bits, excluding bits inserted for transparency.

As a typical implementation, at the transmitting signalling link terminal, the initial remainder of the division is preset to all 1 s and is then modified by division by the generator polynomial (as described above) on all the fields of the signal unit; the 1 s complement of the resulting remainder is transmitted as the 16 check bits.

At the receiving signalling link terminal, the correspondence between the check bits and the remaining part of the signal unit is checked; if a complete correspondence is not found the signal unit is discarded.

As a typical implementation at the receiving signalling link terminal, the initial remainder is preset to all 1 s, and the serial incoming protected bits including the check bits (after the bits inserted for transparency are removed) when divided by the generator polynomial will result in a remainder of 0001110100001111 (x^{15} through x^0, respectively) in the absence of transmission errors.

5 Basic error correction method

5.1 General

The basic error correction method is a noncompelled method in which correction is performed by retransmission. In normal operation, the method ensures correct transfer of message signal units over the signalling link, in sequence and with no double delivery. As a consequence, no resequencing or eliminating of the received information is required within the user parts.

Positive acknowledgements are used to indicate correct transfer of message signal units. *Negative acknowledgements* are used as explicit requests for retransmission of signal units received in a corrupt form.

To minimize the number of retransmissions and the resulting message signal unit delay, a request for retransmission is made only when a message signal unit (not another signal unit) has been lost because of, for example, transmission errors or disturbances.

The method requires that transmitted but not yet positively acknowledged message signal units remain available for retransmission. To maintain the correct message signal unit sequence when a retransmission is made, the message signal unit, the retransmission of which has been requested, and any subsequently transmitted message signal units are retransmitted in the order in which they were originally transmitted.

As part of the error correction method, each signal unit carries a forward sequence number, a *forward indicator bit*, a backward sequence number and a *backward indicator bit*. The error correction procedure operates independently in the two transmission directions. The forward sequence number and forward indicator bit in one direction together with the backward sequence number and backward indicator bit in the other direction are associated with the message signal unit flow in the first direction. They function independently of the message signal unit flow in the other

direction and its associated forward sequence number, forward indicator bit, backward sequence number and backward indicator bit.

The transmission of new message signal units is temporarily stopped during retransmissions or when no forward sequence number values are available to be assigned to new message signal units (due to a high momentary load or corruption of positive acknowledgements) (see 5.2.2).

Under normal conditions, when no message signal units are to be transmitted or retransmitted, fill-in signal units are sent continuously. In some particular cases link status signal units, continuous fill-in signal units or flags may be sent as described in clauses 7, 8 and 11.

5.2 Acknowledgements (positive acknowledgement and negative acknowledgement)

5.2.1 Sequence numbering

For the purposes of acknowledgement and signal unit sequence control, each signal unit carries two sequence numbers. The signal unit sequence control is performed by means of the forward sequence number. The acknowledgement function is performed by means of the backward sequence number.

The value of the forward sequence number of a message signal unit is obtained by incrementing (modulo 128, see 2.3.5) the last assigned value by 1.

This forward sequence number value uniquely identifies the message signal unit until its delivery is accepted without errors, and in correct sequence, by the receiving terminal. The forward sequence number of a signal unit other than a message signal unit assumes the value of the forward sequence number of the last transmitted message signal unit.

5.2.2 Signal unit sequence control

Information regarding the service information octet, signalling information field, forward sequence number and the length of each message signal unit is retained at the transmitting signalling link terminal until a positive acknowledgement for that signal unit is received (see 5.2.3). In the meantime the same forward sequence number cannot be used for another message signal unit (see 5.2.3).

A forward sequence number value can be assigned to a new message signal unit when a positive acknowledgement concerning that value incremented by at least 1 (modulo 128) is received (see 5.2.3).

This means that not more than 127 message signal units may be available for retransmission.

The action to be taken at the receiving signalling link terminal upon receipt of a correctly checking signal unit is determined by comparison of the received forward sequence number with the forward sequence number of the last previously accepted signal unit, and on comparison of the received forward indicator bit with the latest sent backward indicator bit. In addition, as the appropriate action differs for a message signal unit and another signal unit, the length indicator of the received signal unit must be examined.

a) If the signal unit is a fill-in signal unit then:

   i) if the forward sequence number value equals the forward sequence number value of the last accepted message signal unit, the signal unit is processed within the message transfer part;

   ii) if the forward sequence number value is different from the forward sequence number of the last accepted message signal unit, the signal unit is processed within the message transfer part. If the received forward indicator bit is in the same state as the last sent backward indicator bit, a negative acknowledgement is sent.

b) If the signal unit is a link status signal unit, then it is processed within the message transfer part.

c) If the signal unit is a message signal unit then:

   i) if the forward sequence number value is the same as that of the last accepted signal unit, the signal unit is discarded, regardless of the state of the indicator bits;

   ii) if the forward sequence number value is one more (modulo 128, see 2.3.5) than that of the last accepted signal unit and if the received forward indicator bit is in the same state as the last sent backward indicator bit, the signal unit is accepted and delivered to level 3.

   Explicit positive acknowledgements to the accepted signal units are sent as specified in 5.2.3.

   If the forward sequence number is one more than that of the last accepted signal unit and if the received forward indicator bit is not in the same state as the last sent backward indicator bit, then the signal unit is discarded;

   iii) if the forward sequence number value is different from those values mentioned in i) and ii) above, the signal unit is discarded. If the received forward indicator bit is in the same state as the last sent backward indicator bit, a negative acknowledgement is sent.

   Processing of the backward sequence number value and backward indicator bit value as described in 5.3 is performed for message signal units and fill-in signal units except when unreasonable backward sequence number value or unreasonable forward indicator bit value is received. Discarding a signal unit means that if it is a message signal unit, it is not delivered to level 3.

5.2.3 Positive acknowledgement

The receiving signalling link terminal acknowledges the acceptance of one or more message signal units by assigning the forward sequence number value of the latest accepted message signal unit to the backward sequence number of the next signal unit sent in the opposite direction. The backward sequence numbers of subsequent signal units retain this value until a further message signal unit is acknowledged, which will cause a change of the backward sequence number sent.

The acknowledgement to an accepted message signal unit also represents an acknowledgement to all, if any, previously accepted, though not yet acknowledged, message signal units.

5.2.4 Negative acknowledgement

If a negative acknowledgement is to be sent (see 5.2.2), then the backward indicator bit value of the signal units transmitted is inverted. The new backward indicator bit value is maintained in subsequently sent signal units until a new negative acknowledgement is to be sent. The backward sequence number assumes the value of the forward sequence number of the last accepted message signal unit.

5.3 Retransmission

5.3.1 Response to a positive acknowledgement

The transmitting signalling link terminal examines the backward sequence number value of the received message signal units and fill-in signal units that have satisfied the polynomial error check. The previously sent message signal unit, which has a forward sequence number value identical to the received backward sequence number value, will no longer be available for transmission.

When an acknowledgement of a message signal unit having a given forward sequence number value is received, all other message signal units which preceded that message signal unit are considered to be acknowledged even though the corresponding backward sequence numbers have not been received.

In the case that the same positive acknowledgement is consecutively received a number of times, no further action is taken.

In the case that a message signal unit or fill-in signal unit is received having a backward sequence number value which is not the same as the previous one or one of the forward sequence number values of the signal units available for retransmission, the signal unit is discarded. The following message signal unit or fill-in signal unit is discarded.

If any two backward sequence number values in three consecutively received message signal units or fill-in signal units are not the same as the previous one or any of the forward sequence number values of the signal units in the retransmission buffer at the time that they are received, then level 3 is informed that the link is faulty.

A timing mechanism, timer T7[2], shall be provided which generates an indication of excessive delay of acknowledgement if, assuming that there are at least one outstanding MSU in the retransmission buffer, no new-acknowledgement has been received within a time-out T7 (see 12.3). In the case of excessive delay in the reception of acknowledgements, a link failure indication is given to level 3.

5.3.2 Response to a negative acknowledgement

When the received backward indicator bit is not in the same state as the last sent forward indicator bit, all the message signal units available for retransmission are transmitted in correct sequence starting with the signal unit which has a forward sequence number value of one more (modulo 128, see 2.3.5) than the backward sequence number associated with the received backward indicator bit.

New message signal units can only be sent when the last message signal unit available for retransmission has been transmitted.

At the start of a retransmission the forward indicator bit is inverted, it thus becomes equal to the backward indicator bit value of the received signal units. The new forward indicator bit value is maintained in subsequently transmitted signal units until a new retransmission is started. Thus, under normal conditions the forward indicator bit included in the transmitted signal units is equal to the backward indicator bit value of the received signal units. If a retransmitted message signal unit is lost, then this is detected by a check on the forward sequence number and forward indicator bit (see 5.2.2) and a new retransmission request is made.

In the case that a message signal unit or a fill-in signal unit is received having a forward indicator bit value indicating the start of a retransmission when no negative acknowledgement has been sent, then that signal unit is discarded. The following message signal unit or fill-in signal unit is discarded.

If any two forward indicator bit values in three consecutively received message signal units or fill-in signal units indicate the start of a retransmission when no negative acknowledgement has been sent at the time that they are received, then level 3 is informed that the link is faulty.

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2 Timers defined in this Recommendation are absolute time values. This means that, due to the possibility to insert multiple flags between signal units (see 3.1), there may be no fixed relation between the time-out values and the number of signal units transmitted/received during the time-out periods.

5.3.3 Repetition of message signal units

The signal unit sequence control makes it possible to repeat a message signal unit which has not yet been acknowledged without affecting the basic error correction procedure. Thus a form of forward error correction by means of repetition of message signal units is possible as a national option (e.g. to reduce the effective signalling link speed in special national applications, and in long loop delay applications to lower the retransmission rate and thus reduce the average message delay). In the case of repetition, each signal unit should be defined by its own opening and closing flags (i.e. there should be at least two flags between signal units) to ensure that the repeated signal unit is not lost by the corruption of only a single flag.

6 Error correction by preventive cyclic retransmission

6.1 General

The preventive cyclic retransmission method is essentially a noncompelled forward error correction method, whereby positive acknowledgements are needed to support the forward error correction.

Each message signal unit must be retained at the transmitting signalling link terminal until a positive acknowledgement arrives from the receiving signalling link terminal.

Error correction is effected by preventive cyclic retransmission of the message signal units already sent, though not yet acknowledged. Preventive cyclic retransmission takes place whenever there are no new message signal units or link status signal units available to be sent.

To complement preventive cyclic retransmission, the message signal units available for retransmission are retransmitted with priority when a limit of the number of message signal units or a limit of the number of message signal unit octets available for retransmission has been reached.

Under normal conditions, when no message signal units are to be transmitted or cyclically retransmitted, fill-in signal units are sent. In some particular cases link status signal units, continuous fill-in signal units or flags may be sent as described in clauses 7, 8 and 11.

6.2 Acknowledgements

6.2.1 Sequence numbering

For the purposes of acknowledgement and signal unit sequence control, each signal unit carries 2 sequence numbers. The signal unit sequence control is performed by means of the forward sequence number. The acknowledgement function is performed by means of the backward sequence number.

The value of the forward sequence number of a message signal unit is obtained by incrementing (modulo 128, see 2.3.5) the last assigned value by 1. This forward sequence number value uniquely identifies the message signal unit until its delivery is accepted without errors and in correct sequence, by the receiving signalling link terminal. The forward sequence number of a signal unit other than a message signal unit assumes the value of the forward sequence number of the last transmitted message signal unit.

6.2.2 Signal unit sequence control

Information regarding the service information octet, signalling information field, forward sequence number and the length of each message signal unit is retained at the transmitting signal link terminal until the related acknowledgement for that signal unit is received (see 6.2.3). In the meantime the same forward sequence number value cannot be used for another message signal unit (see 6.2.3).

A forward sequence number value can be assigned to a new message signal unit to be sent when a positive acknowledgement concerning that value incremented by at least 1 (modulo 128) is received (see 6.2.3).

The action to be taken at the receiving signalling link terminal upon receipt of a correctly checking signal unit is determined by comparison of the received forward sequence number with the forward sequence number of the last previously accepted signal unit.

In addition, as the appropriate action differs for a message signal unit and another signal unit, the length indicator of the received signal unit must be examined. The forward indicator bit and the backward indicator bit are not used and are set to 1.

a) If the signal unit is not a message signal unit, then the signal unit is processed within the message transfer part.

b) If the signal unit is a message signal unit then:

   i) if the forward sequence number value is the same as that of the last accepted signal unit, the signal unit is discarded;

   ii) if the forward sequence number value is one more (modulo 128, see 2.3.5) than that of the last accepted signal unit, the signal unit is accepted and delivered to level 3. Explicit positive acknowledgements for the accepted signal units are sent as specified in 6.2.3;

   iii) if the forward sequence number value is different from the values mentioned in i) and ii) above, the signal unit is discarded. Processing of the backward sequence number value as described in 6.3 is performed for message signal units and fill-in signal units except when unreasonable backward sequence number value is received. Discarding a signal unit means that if it is a message signal unit, it is not delivered to level 3.

6.2.3 Positive acknowledgement

The receiving signalling link terminal acknowledges the acceptance of one or more message signal units by assigning the forward sequence number value of the latest accepted message signal unit to the backward sequence number of the next signal unit sent. The backward sequence numbers of subsequent signal units retain this value until a further message signal unit is acknowledged, which will cause a change of the backward sequence number sent. The acknowledgement to an accepted message signal unit also represents an acknowledgement to all, if any, previously accepted though not yet acknowledged signal units.

6.3 Preventive cyclic retransmission

6.3.1 Response to a positive acknowledgement

All message signal units sent for the first time are retained until they have been positively acknowledged.

The transmitting signalling link terminal examines the backward sequence number value of the received message signal units and fill-in signal units that have satisfied the polynomial error check. The previously sent message signal unit, the forward sequence number value of which is the same as the backward sequence number value, will no longer be available for retransmission.

When an acknowledgement for a message signal unit having a given forward sequence number value is received, all other message signal units, if any, having forward sequence number values preceding that value (modulo 128) are considered to be acknowledged, even though the corresponding backward sequence number has not been received.

In the case that the same positive acknowledgement is consecutively received a number of times, no further action is taken.

In the case that a message signal unit or fill-in signal unit is received having a backward sequence number value which is not the same as the previous one or one of the forward sequence number values of the signal units in the retransmission buffer, the signal unit is discarded. The following message signal unit or fill-in signal unit is discarded.

If any two backward sequence number values in three consecutively received message signal units or fill-in signal units are not the same as the previous one or any of the forward sequence number values of the signal units in the retransmission buffer at the time that they are received, then level 3 is informed that the link is faulty.

A timing mechanism, timer T7, shall be provided which generates an indication of excessive delay of acknowledgement if, assuming that there is at least one outstanding MSU in the retransmission buffer, no new acknowledgement has been received within a time-out T7 (see 12.3). In the case of excessive delay in the reception of acknowledgements, a link failure indications is given to level 3.

6.3.2 Preventive cyclic retransmission procedure

i) If no new signal units are available to be sent, the message signal units available for retransmission are retransmitted cyclically.

ii) If new signal units are available, the retransmission cycle, if any, must be interrupted and the signal units be sent with priority.

iii) Under normal conditions, when no message signal units are to be transmitted or cyclically retransmitted, fill-in signal units are sent continuously. In some particular cases link status signal units, continuous fill-in signal units or flags may be sent as described in clauses 7, 8 and 10.

6.4 Forced retransmission

To maintain the efficiency of error correction in those cases where automatic error correction by preventive cyclic retransmission alone is made impossible (by, for example, high signalling load), the preventive cyclic retransmission procedures must be complemented by the forced retransmission procedure.

6.4.1 Forced retransmission procedure

Both the number of message signal units available for retransmission (N_1) and the number of message signal unit octets available for retransmission (N_2) are monitored continuously.

If one of them reaches its set limit, no new message signal units or fill-in signal units are sent and the retransmission cycle is continued up to the last message signal unit entered into retransmission buffer with priority, in the order in which they were originally transmitted. If all those message signal units have been sent once and neither N_1 nor N_2 is at its limit value, the normal preventive cyclic retransmission procedure can be resumed. If not, all the message signal units available for retransmission are sent again with priority.

6.4.2 Limitation of the values N_1 and N_2

N_1 is limited by the maximum numbering capacity of the forward sequence number range which dictates that not more than 127 message signal units can be available for retransmission.

In the absence of errors, N_2 is limited by the signalling link loop delay T_L. It must be ensured that not more than $T_L/T_{eb} + 1$ message signal unit octets are available for retransmission,

where:

T_L is the signalling link loop delay, i.e. the time between the sending of a message signal unit and the reception of the acknowledgement for this message signal unit in undisturbed operation; and

T_{eb} is the emission time of one octet.

When some signalling data links of different loop delays are alternated for application to that signalling link, the longest possible signalling link delay may be used to calculate the value of T_L.

7 Initial alignment procedure

7.1 General

The procedure is applicable to activation and to restoration of the link. The procedure provides a "normal" proving period for "normal" initial alignment and an "emergency" proving period for "emergency" initial alignment. The decision to apply either the "normal" or the "emergency" procedures is made unilaterally at level 3 (see Recommendation Q.704). Only the signalling link to be aligned is involved in the initial alignment procedure (i.e. no transfer of alignment information over other signalling links is required).

7.2 Initial alignment status indications

The initial alignment procedure employs four different alignment status indications:

– status indication "O": out of alignment;

– status indication "N": "normal" alignment status;

– status indication "E": "emergency" alignment status;

– status indication "OS": out of service.

These indications are carried in the status field of the link status signal units (see 2.2).

Status indication "O" is transmitted when initial alignment has been started and none of the status indications "O", "N" or "E" are received from the link. Status indication "N" is transmitted when, after having started initial alignment, status indication "O", "N" or "E" is received and the terminal is in the "normal" alignment status. Status indication "E" is transmitted when, after having started initial alignment, status indication "O", "N" or "E" is received and the terminal is in the "emergency" alignment status, i.e. it must employ the short "emergency" proving period.

Status indications "N" and "E" indicate the status of the transmitting signalling link terminal; this is not changed by reception of status indications indicating a different status at the remote signalling link terminal. Hence, if a signalling link terminal with a "normal" alignment status receives a status indication "E" it continues to send status indication "N" but initiates the short "emergency" proving period.

Status indication "OS" informs the remote signalling link terminal that for reasons other than processor outage (e.g. link failure) the signalling link terminal can neither receive nor transmit message signal units. Status indication OS is sent on completion of "power on" (see Figures 2 and 8) until initial alignment is started.

7.3 Initial alignment procedure

The alignment procedure passes through a number of states during the initial alignment:

– State Idle: The procedure is suspended.

- State "not aligned": The signalling link is not aligned and the terminal is sending status indication "O". Time-out T2[3] is started on entry to State and stopped when State is left[4].
- State "aligned": The signalling link is aligned and the terminal is sending status indication "N" or "E", status indications "N", "E" or "OS" are not received. Time-out T3[3] is started on entry to State and stopped when State is left.
- State 03, "proving": The signalling link terminal is sending status indication "N" or "E", status indication "O" or "OS" are not received, proving has been started.

  Proving is the means by which the signalling link terminal validates the link's ability to carry signal units correctly by inspecting the signal units. «Proving» must last for a period of T4 before the link can enter the «aligned ready» link state. Expiry of timer T4 (see 12.3) indicates a successful proving period unless the proving period has been previously aborted up to four times.
- Following successful alignment and proving procedure, the signalling terminal enters Aligned Ready state and the aligned ready time-out T1 is stopped on entry in the In-service state and the duration of time-out T1 should be chosen such that the remote end can perform four additional proving attempts.

The procedure itself is described in the overview diagram, Figure 4, and in state transition diagram, Figure 9.

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3 Timers defined in this Recommendation are absolute time values. This means that, due to the possibility to insert multiple flags between signal units (see 3.1), there may be no fixed relation between the time-out values and the number of signal units transmitted/received during the time-out periods.

4 If automatic allocation of signalling terminals or signalling data links is applied at both ends of a signalling link, it must be ensured that the values of this time-out are different at each end of a signalling link (see clause 12/Q.704). In this case T2 low (see 12.3) is allocated to the signalling point with the lower point code and T2 high to the signalling point with the higher point code. In all other cases, the value of time-out T2 can be the same at both ends of the link.

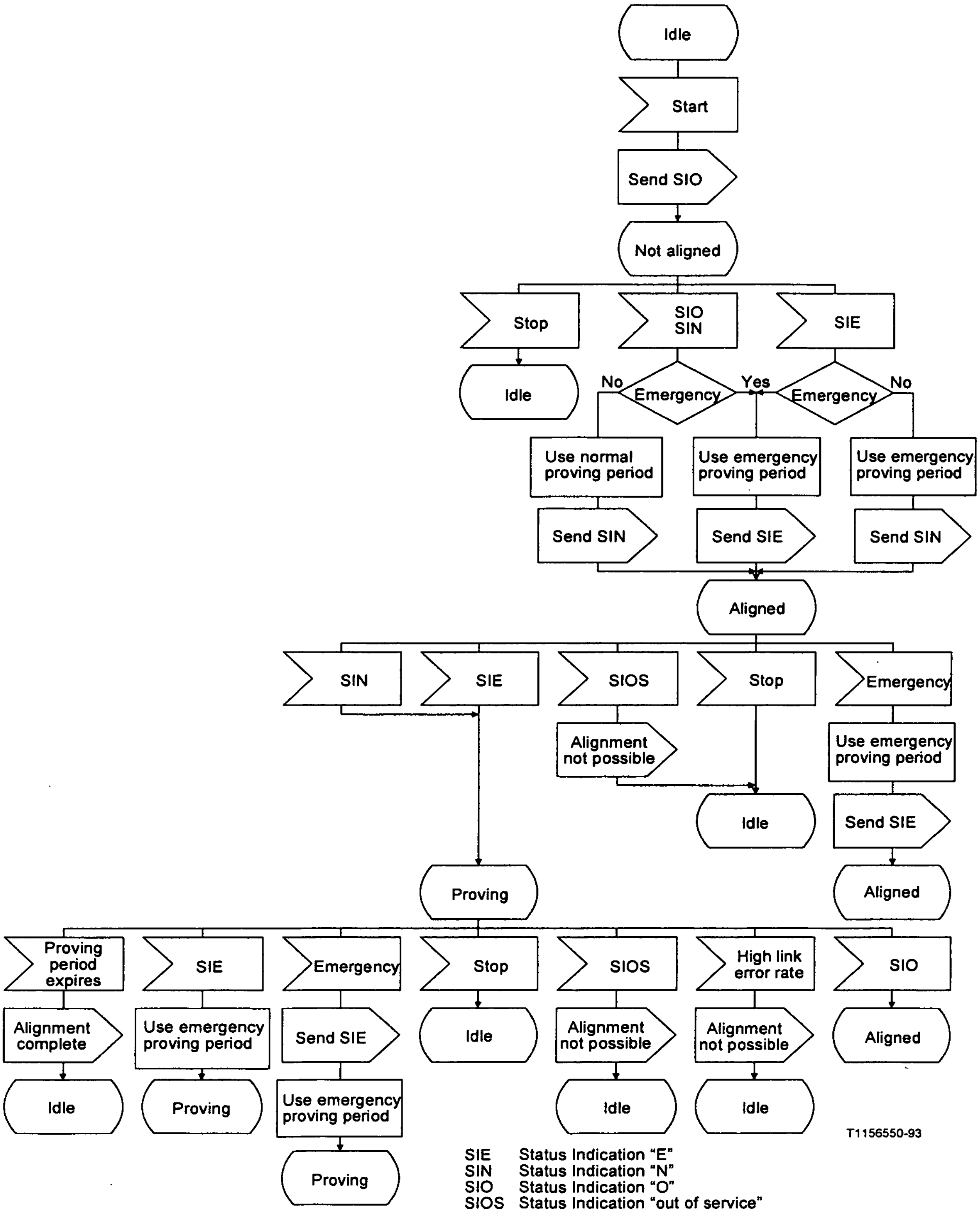


Figure 4/Q.703 – Overview diagram of initial alignment control

7.4 Proving periods

The nominal values of the proving periods are:

$P_n = 2^{16}$ octets transmission time;

$P_e = 2^{12}$ octets transmission time,

for both 64 kbit/s and lower bit rates. For the corresponding timer T4 values (proving periods), see 12.3.

8 Processor outage

The procedure for dealing with local and/or remote processor outage is described in Figure 10.

A processor outage situation occurs when, due to factors at a functional level higher than level 2, use of the link is precluded.

In this context, processor outage refers to a situation when signalling messages cannot be transferred to functional levels 3 and/or 4. This may be because of, for example, a central processor failure. A processor outage condition may not necessarily affect all signalling links in a signalling point, nor does it exclude the possibility that level 3 is able to control the operation of the signalling link.

When level 2 identifies a local processor outage condition, it transmits link status signal units indicating processor outage and discards message signal units received. Provided that the level 2 function at the far end of the signalling link is in its normal operating state (i.e. transmitting message signal units or fill-in signal units), upon receiving link status signal units indicating processor outage, it notifies level 3 and begins continuously to transmit fill-in signal units.

When the local processor outage condition ceases, normal transmission of message signal units and fill-in signal units is resumed (provided that no local processor outage condition has arisen also at the remote end). As soon as the level 2 function at the remote end correctly receives a message signal unit or fill-in signal unit, it notifies level 3 and returns to the In service state[5]. However, in order to avoid problems with the flushing of old messages, it is recommended that level 2 on both sides should wait to resume its normal operation after it is explicitly notified by level 3 that it may do so.

It should be noted that in the case that processor outage is of "long term", i.e. when timer T1 in MTP level 3 (see 16.8/Q.704) has expired, problems exist with old messages, which are those messages stored within level 2 buffers after the switch of new traffic on the alternative link(s) has been performed. This is because, in general, the level 2 buffers on both sides of the link contain some MSUs. If normal operation of the link is resumed, (re)transmission of these messages would result in message missequencing. Furthermore, it is very likely that these messages are related to calls that have already been released or to network management situations that have long since passed.

Because of the above, in order to avoid sending of old messages, the level 2 buffers on both sides should be flushed immediately after the local/remote processor outage state terminates. In addition, the synchronization of the level 2 sequence numbers has to be assured. This is necessary for the correct operation of the link. It is understood that each side is responsible for the flushing and synchronization concerning its own level 2 and that the specific actions concerning the synchronization of the level 2 sequence numbers must not rely on the actions of the other side. How these measures are performed is considered to be implementation dependent.

Format and code of link status signal units indicating processor outage (status indication "PO") appear in clause 11.

[5] Whether the just received MSU/FISU and a limited number of following ones are discarded or not is an implementation dependent decision.

9 Level 2 flow control

9.1 General

The procedure is used to handle a level 2 congestion situation. After the congestion is detected at the receiving end of the signalling link, both positive and negative acknowledgements to message units are withheld and a status indication "B" (Busy) is sent from the receiving end of the link to the remote end in order to enable the remote transmitting end to distinguish between congestion and failure situations.

This indication is carried in the status field of a link status signal unit.

NOTE – The receiving end continues to process BSN and BIB carried in signal units received in order to avoid, as far as possible, disturbance of the message flow in the opposite direction and in addition may continue to accept message signal units.

9.2 Detection of congestion

The mechanism for detecting congestion at the receiving end of a signalling link is implementation dependent and not to be specified.

9.3 Procedure in the congestion situation

The receiving end of a signalling link which detected a congestion situation, periodically returns a link status signal unit containing a status indication "B" to the remote transmitting end of the link at interval T5 (see 12.3).

The receiving level 2 also withholds acknowledgement of the message signal unit, which triggered off the congestion detection, and of message signal units received during the congestion situation; that is fill-in signal units or message signal units are sent as usual, but with the backward sequence number and backward indicator bit assigned the values which are contained in the last transmitted signal unit before the congestion is recognized.

At the remote end of the signalling link, every reception of a link status signal unit containing indication "B" causes the excessive delay of acknowledgement timer T7 to be restarted, if the timer is already running. In addition first reception of the link status signal unit containing a status indication "B" starts a longer supervision timer T6 (see 12.3) only if there are message signal units in the retransmission buffer. Should timer T6 expire, link failure indication is generated.

9.4 Congestion abatement procedure

When congestion abates at the receiving end of the signalling link, transmission of link status signal unit containing a status indication "B" is stopped and normal operation resumed.

At the remote end, the supervision timer T6 is stopped when a negative or positive acknowledgement whose backward sequence number acknowledges a message signal unit in the retransmission buffer is received in case of the basic error correction method, or a positive acknowledgement in case of the PCR method.

NOTE – Congestion onset and abatement detection is an implementation dependent function. Sufficient hysteresis should be provided in the implementation to prevent excessive oscillation between congested and non-congested states.

10 Signalling link error monitoring

10.1 General

Two link error rate monitor functions are provided: one which is employed whilst a signalling link is in service and which provides one of the criteria for taking the link out of service, and one which is employed whilst a link is in the proving state of the initial alignment procedure (see 7.3). These are called the signal unit error rate monitor and the alignment error rate monitor respectively.

10.2 Signal unit error rate monitor

10.2.1 The signal unit error rate monitor has as its function the estimation of the signal unit error rate in order to decide about the signalling link fault condition. The signal units in error are those rejected by the acceptance procedure (see clause 4). The three parameters which determine the signal unit error rate monitor are: the number T (signal units), of consecutive signal units received in error that will cause an error rate high indication to level 3, the lowest signal unit error rate $1/D$ (signal unit errors/signal unit) which will ultimately cause an error rate high indication to level 3, and the number N (octets) of octets that causes an increment of the counter while in the "octet counting" mode. See Figure 5.

10.2.2 The signal unit error rate monitor may be implemented in the form of an up/down counter decremented at a fixed rate (for every D received signal units or signal unit errors indicated by the acceptance procedure), but not below zero, and incremented every time a signal unit error is detected by the signal unit acceptance procedure (see clause 4), but not above the threshold [T (signal units)]. An excessive error rate will be indicated whenever the threshold T is reached.

10.2.3 In the "octet counting" mode (see 4.1) the counter is incremented for every N octets received until a correctly-checking signal unit is detected (causing the "octet counting" mode to be left).

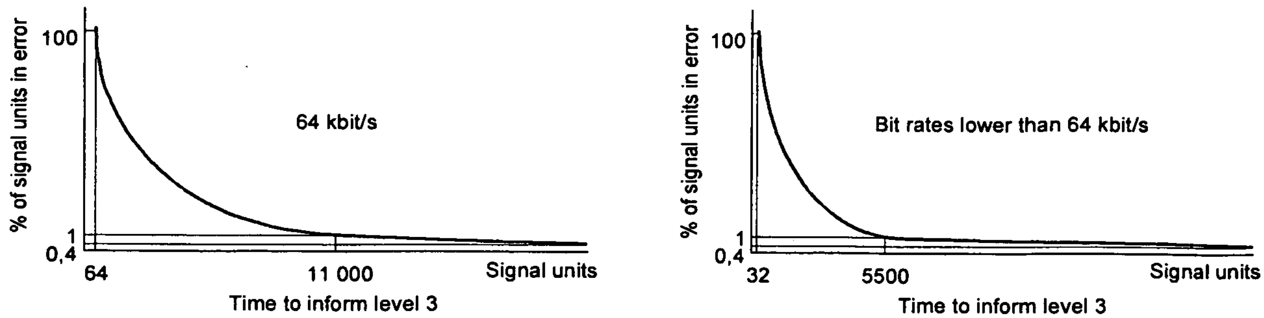
10.2.4 When the link is brought into service the monitor count should start from zero.

10.2.5 The values of the three parameters are:

T	=	64 signal units	For 64 kbit/s
D	=	256 signal units/signal unit error	For 64 kbit/s
N	=	16 octets	For 64 kbit/s
T	=	32 signal units	For lower bit rates
D	=	256 signal units/signal unit error	For lower bit rates
N	=	16 octets	For lower bit rates

In the case of loss of alignment, these figures will give times of approximately 128 ms and 854 ms to initiate changeover for 64 kbit/s and 4.8 kbit/s respectively.

10.2.6 In the case where only random signal unit errors occur over the signalling link, the relationship between the expected number of signal units until threshold of T (signal units) is reached and the signal unit errors rate (signal unit errors/signal units) can be established. This relationship may be expressed by an orthogonal hyperbola which has parameters (T, $1/D$) (see Figure 5).



T1156560-93

Figure 5/Q.703 – Relationship between the expected number of signal units to fault indication and signal units errors rates

10.3 Alignment error rate monitor

10.3.1 The alignment error rate monitor is a linear counter which is operated during normal and emergency proving periods.

10.3.2 The counter is started from zero whenever the proving state (see Figure 9) of the alignment procedure is entered and is then incremented for every signal unit error detected, if not in the octet counting mode. It is also incremented for every N octets received while in the octet counting mode, as described in 10.2.3.

10.3.3 When the counter reaches a threshold T_i, that particular proving period is aborted; on receipt of a correct signal unit or the expiry of the aborted proving period the proving state is reentered. If proving is aborted M times, the link is returned to the out-of-service state. A threshold is defined for each of the two types of proving period (normal and emergency, see clause 7). These are T_{in} and T_{ie} and apply to the normal proving period and the emergency proving period respectively.

Proving is successfully completed when a proving period expires without an excessive error rate being detected and without the receipt of status indication "O" or "OS".

10.3.4 The values of the four parameters for both 64 kbit/s and lower bit rates are:

$T_{in} = 4$

$T_{ie} = 1$

$M = 5$

$N = 16$

NOTE – It is noted that the emergency proving period may be successfully completed with some probability with a marginal and degraded bit error rate, i.e. around one error in 10^4 bits - subsequently, the SUERM will quickly indicate an excessive error rate. However, short term operation on a degraded link may be acceptable (e.g. to send management messages).

11 Level 2 codes and priorities

11.1 Link status signal unit

11.1.1 The link status signal unit is identified by a length indicator value equal to 1 or 2. If the length indicator has a value of 1 then the status field consists of one octet; if the length indicator has a value of 2 then the status field consists of two octets.

11.1.2 The format of the one octet status field is shown in Figure 6.

When a terminal, which is able to process only a one-octet status field, receives a link status signal unit with a two-octet status field, the terminal shall ignore the second octet for compatibility reasons but process the first octet as specified.

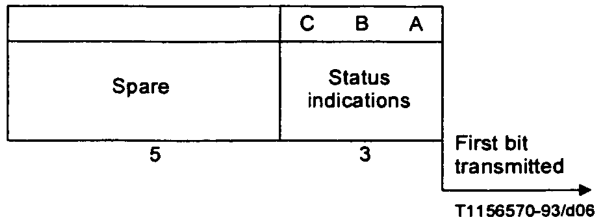


Figure 6/Q.703 – Status field format

11.1.3 The use of the link status indications is described in clause 7. They are coded as follows:

C	B	A
0	0	0 – Status indication "O"
0	0	1 – Status indication "N"
0	1	0 – Status indication "E"
0	1	1 – Status indication "OS"
1	0	0 – Status indication "PO"
1	0	1 – Status indication "B"

The spare bits should be ignored at the receiving side.

NOTE – For the use of spare bit D in the national option for a SIF compatibility mechanism, see 7.2.6/Q.701.

11.2 Transmission priorities within level 2

11.2.1 Five different items can be transmitted:

i) new message signal units;

ii) message signal units which have not yet been acknowledged;

iii) link status signal units;

iv) fill-in signal units;

v) flags.

In certain failure conditions, it may only be possible to send flags or nothing at all.

11.2.2 For the basic error control method, the priorities are:

Highest 1. Link status signal units.

2. Message signal units which have not yet been acknowledged and for which a negative acknowledgement has been received.

3. New message signal units.

4. Fill-in signal units.

Lowest 5. Flags.

11.2.3 For the preventive cyclic retransmission method, the priorities are:

Highest 1. Link status signal units.

2. Message signal units which have not yet been acknowledged and which are stored in a retransmission buffer and exceed one of the parameters N_1 and N_2.

3. New message signal units.

4. Message signal units which have not yet been acknowledged.

5. Fill-in signal units.

Lowest 6. Flags.

NOTE – In the basic error control method, where the repetition of message signal units is employed as a national option, the repeated message signal unit will have a priority immediately below that of link status signal units.

12 State transition diagrams, abbreviations and timers

12.1 This clause contains the description of the signalling link control functions, described in this Recommendation, in the form of state transition diagrams according to the CCITT Specification and Description Language (SDL). The following list summarizes these diagrams:

- Level 2 – Functional block diagram: Figure 7.
- Link State Control (LSC): Figure 8.
- Initial Alignment Control (IAC): Figure 9.
- Processor Outage Control (POC): Figure 10.
- Delimitation, Alignment and Error Detection (Receiving) (DAEDR): Figure 11.
- Delimitation, Alignment and Error Detection (Transmitting) (DAEDT): Figure 12.
- Basic Transmission Control (TC): Figure 13.
- Basic Reception Control (RC): Figure 14.
- Preventive Cyclic Retransmission – Transmission Control (PCR-TC): Figure 15.
- Preventive Cyclic Retransmission – Reception Control (PCR-RC): Figure 16.
- Alignment Error Rate Monitor (AERM): Figure 17.
- Signal Unit Error Rate Monitor (SUERM): Figure 18.
- Congestion Control part (CC): Figure 19.

The detailed functional breakdown shown in the following diagrams is intended to illustrate a reference model and to assist interpretation of the text in the earlier clauses. The state transition diagrams are intended to show precisely the behaviour of the signalling system under normal and abnormal conditions as viewed from a remote location. It must be emphasized that the functional partitioning shown in the following diagrams is used only to facilitate understanding of the system behaviour and is not intended to specify the functional partitioning to be adopted in a practical implementation of the signalling system.

In Figures 7 to 19, the term *signal unit* refers to units which do not contain all error control information.

12.2 Abbreviations

For the purposes of this Recommendation, the following abbreviations apply:

AERM Alignment Error Rate Monitor

BIB Backward Indicator Bit

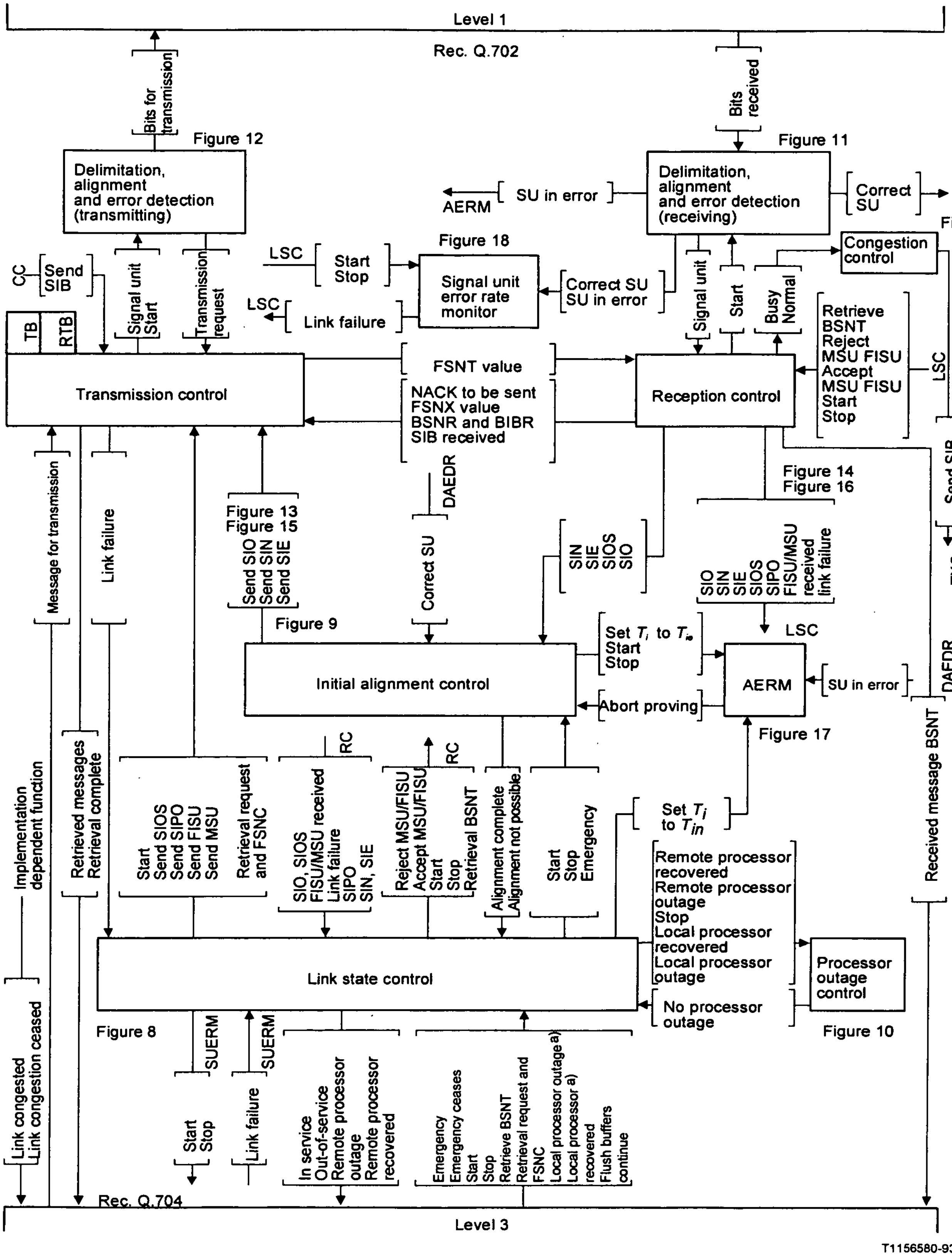
BIBR	BIB received
BIBT	BIB to be transmitted
BIBX	BIB expected
BSN	Backward Sequence Number
BSNR	BSN received
BSNT	BSN to be transmitted
C_p	Count of aborted proving attempts [Figure 9 (sheets 2 of 6 and 3 of 6)]
C_m	Counter of MSU in TB [Figure 13 (sheet 1 of 7) and Figure 15 (sheet 1 of 7)]
C_a	AERM count (Figure 17)
C_s	SUERM count (Figure 18)
CC	Congestion Control
DAEDR	Delimitation, Alignment and Error Detection (Receiving)
DAEDT	Delimitation, Alignment and Error Detection (Transmitting)
FIB	Forward Indicator Bit
FIBR	FIB received
FIBT	FIB transmitted
FIBX	FIB expected
FISU	Fill-In Signal Unit
FSN	Forward Sequence Number
FSNC	Forward sequence number of last message signal unit accepted by remote level 2
FSNF	FSN of the oldest MSU in the RTB
FSNL	FSN of the last MSU in the RTB
FSNR	FSN received
FSNT	FSN of the last MSU transmitted
FSNX	FSN expected
IAC	Initial Alignment Control
L2	Level 2
L3	Level 3
LSC	Link State Control
LSSU	Link Status Signal Unit
MGMT	Management system – Unspecified implementation dependent management function
MSU	Message Signal Unit
NSU	Correct SU count
NACK	Negative acknowledgement
N_1	Maximum number of MSU which are available for retransmission (fixed by the numbering capacity of the FSN)
N_2	Maximum number of MSU octets which are available for retransmission (fixed by the common channel loop delay time)
POC	Processor Outage Control
RC	Reception Control

RTB	Retransmission buffer
RTR	If = 1 means retransmission expected
SIB	Status Indication "B" ("Busy")
SIE	Status Indication "E" ("emergency alignment")
SIN	Status Indication "N" ("normal alignment")
SIO	Status Indication "O" ("out of alignment")
SIOS	Status Indication "OS" ("out of service")
SIPO	Status Indication "PO" ("processor outage")
SU	Signal Unit
SUERM	Signal Unit Error Rate Monitor
TB	Transmission Buffer
T_i	AERM threshold
T_{ie}	Emergency AERM threshold
T_{in}	Normal AERM threshold
TXC	Transmission control
UNB	Counter of unreasonable BSN
UNF	Counter of unreasonable FIB

12.3 Timers

T1		Timer "alignment ready"
	T1 (64) = 40-50 s	Bit rate of 64 kbit/s
	T1 (4.8) = 500-600 s	Bit rate of 4.8 kbit/s
T2 = 5-150 s		Timer "not aligned"
	T2 low = 5-50 s	Only for automatic allocation of
	T2 high = 70-150 s	signalling data links and terminals
T3 = 1-2 s		Timer "aligned"
T4		Proving period timer = 2^{16} or 2^{12} octet transmission time
	T4*n* (64) = 7.5-9.5 s Nominal value 8.2 s	Normal proving period at 64 kbit/s (corresponding to $P_n = 2^{16}$)
	T4*n* (4.8) = 100-120 s Nominal value 110 s	Nominal proving period at 4.8 kbit/s (corresponding to $P_n = 2^{16}$)
	T4*e* (64) = 400-600 ms Nominal value 500 ms	Emergency proving period at 64 kbit/s (corresponding to $P_e = 2^{12}$)
	T4*e* (4.8) = 6-8 s Nominal value 7 s	Emergency proving period at 4.8 kbit/s (corresponding to $P_e = 2^{12}$)
T5 = 80-120 ms		Timer "sending SIB"
T6		Timer "remote congestion"

	T6 (64) = 3-6 s	Bit rate of 64 kbit/s
	T6 (4.8) = 8-12 s	Bit rate of 4.8 kbit/s
T7		Timer "excessive delay of acknowledgement"
	T7 (64) = 0.5-2 s	Bit rate of 64 kbit/s
	For PCR method,	Values less than 0.8 s should not be used
	T7 (4.8) = 4-6 s	Bit rate of 4.8 kbit/s
P_e	Emergency proving period	
P_n	Normal proving period	



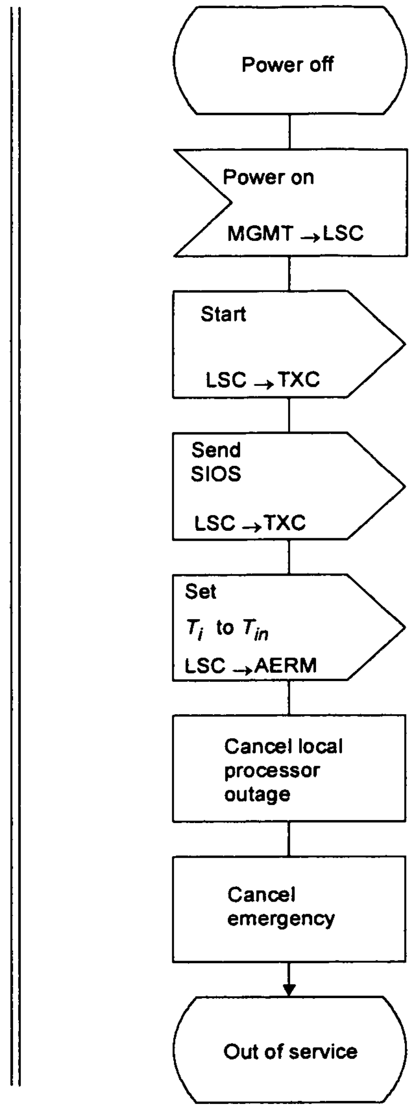
a) Only for the national option of latching of processor outage.

NOTES

1 – Abbreviated message names have been used in this diagram (i.e. origin – destination codes are omitted).

2 – See the abbreviations and timers used in this Figure in 12.2.

Figure 7/Q.703 – Level 2 – Functional block diagram



NOTE – The Notes are found after the last sheet (sheet 14 of 14) of this Figure.

Figure 8/Q.703 (sheet 1 of 14) – Link state control

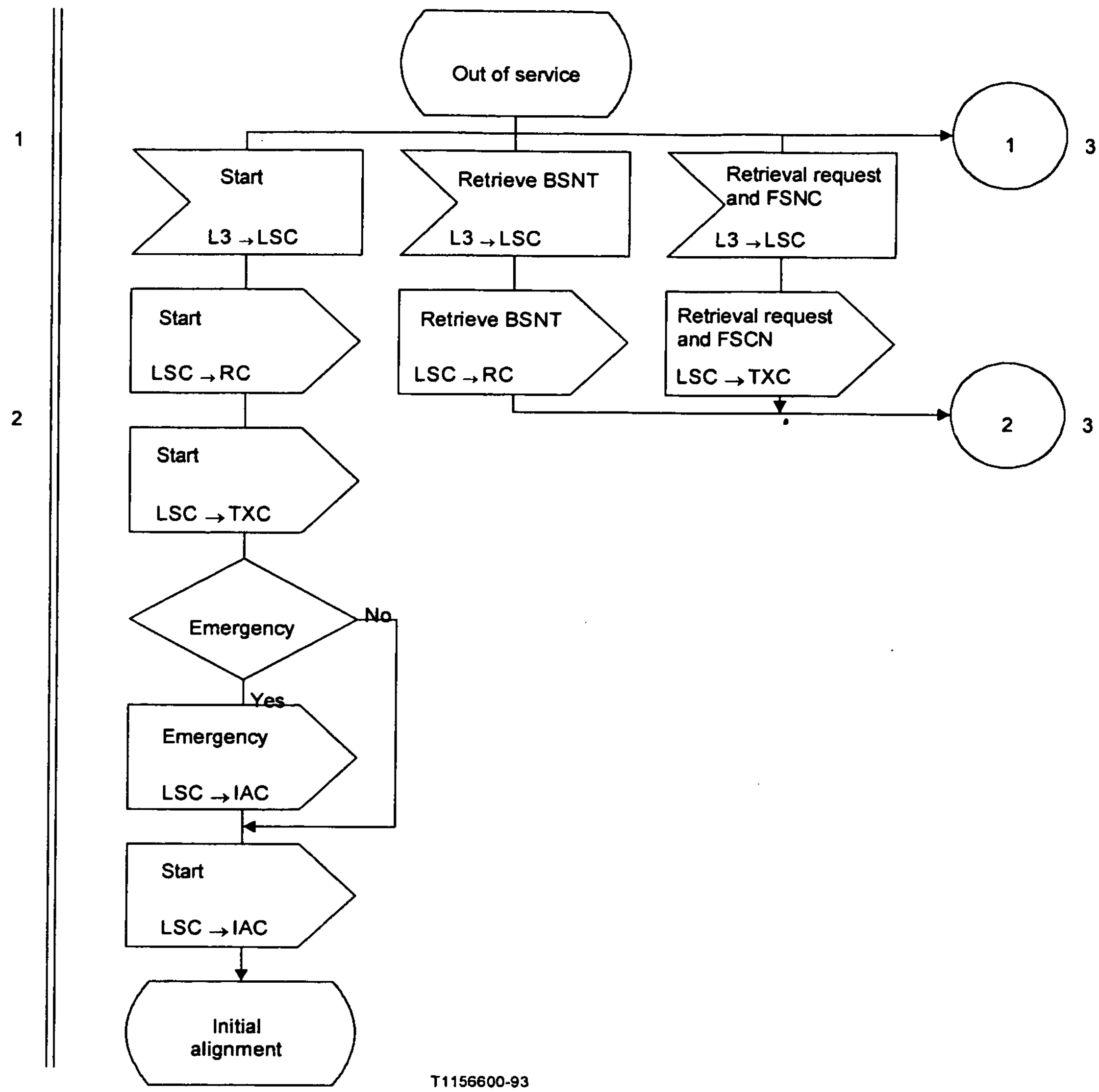


Figure 8/Q.703 (sheet 2 of 14) – Link state control

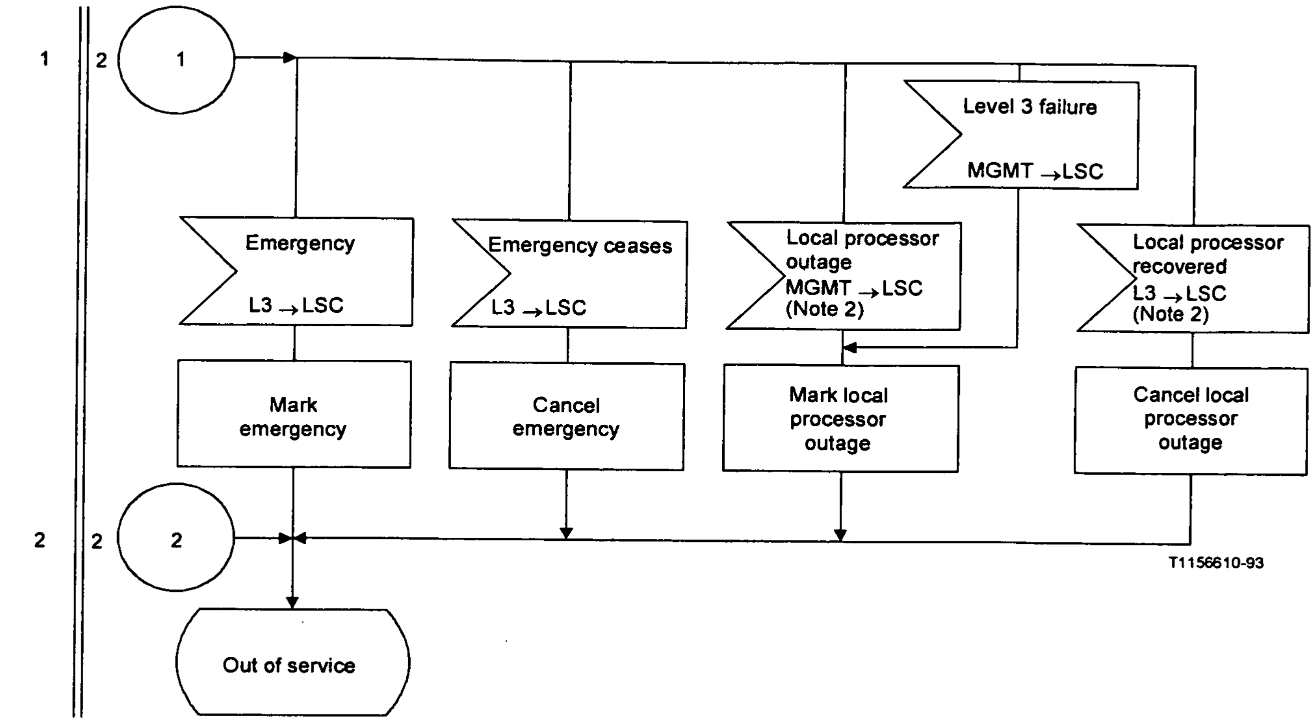


Figure 8/Q.703 (sheet 3 of 14) – Link state control

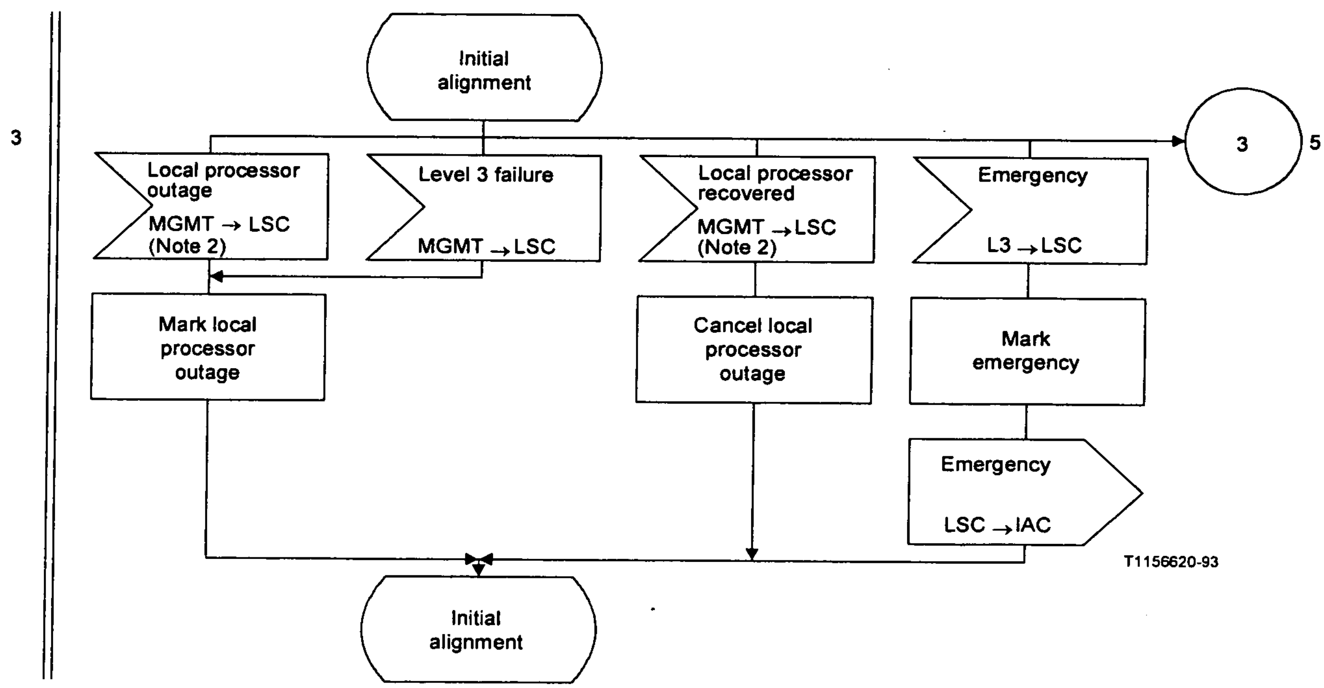


Figure 8/Q.703 (sheet 4 of 14) – Link state control

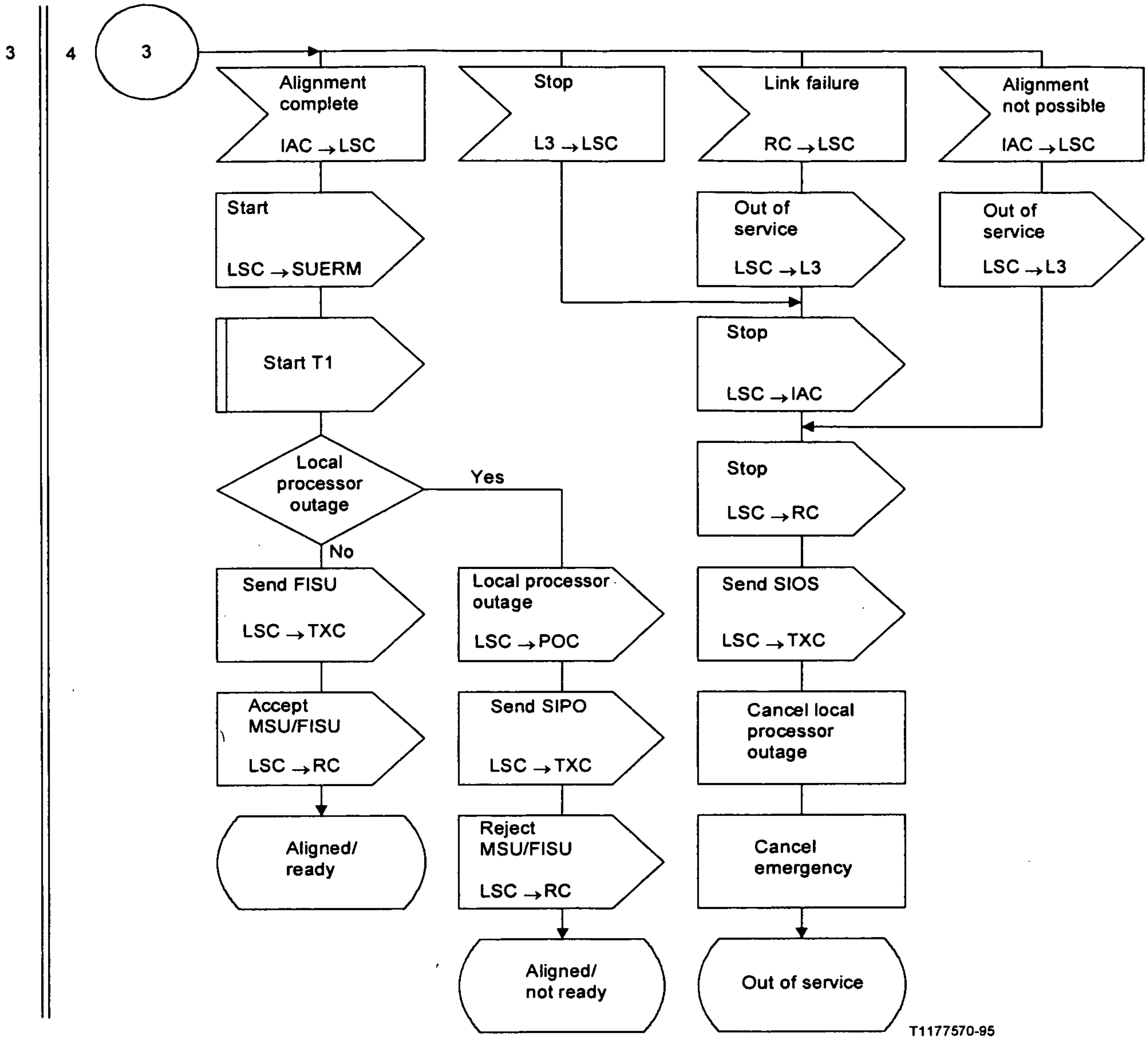


Figure 8/Q.703 (sheet 5 of 14) – Link state control

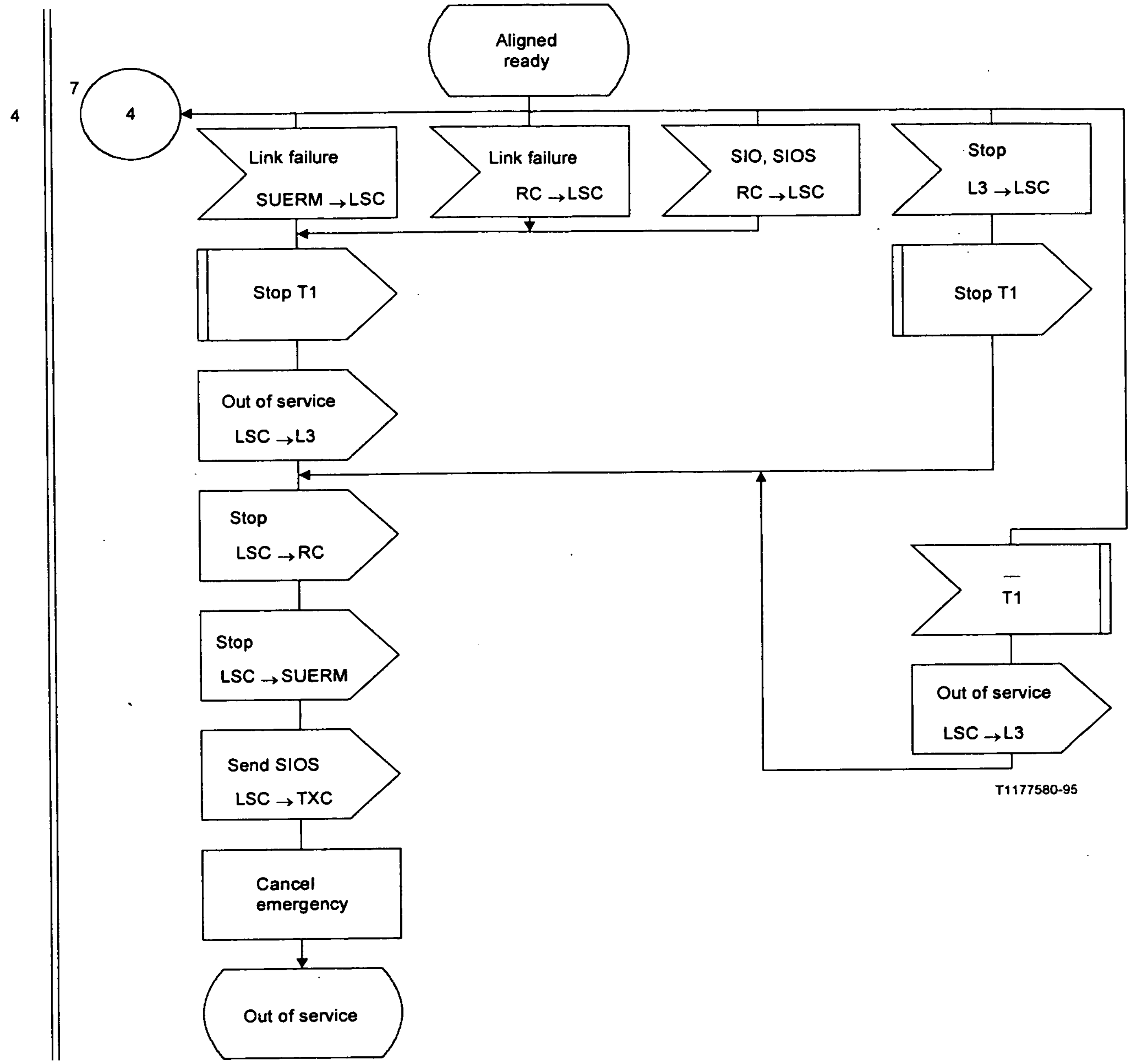


Figure 8/Q.703 (sheet 6 of 14) – Link state control

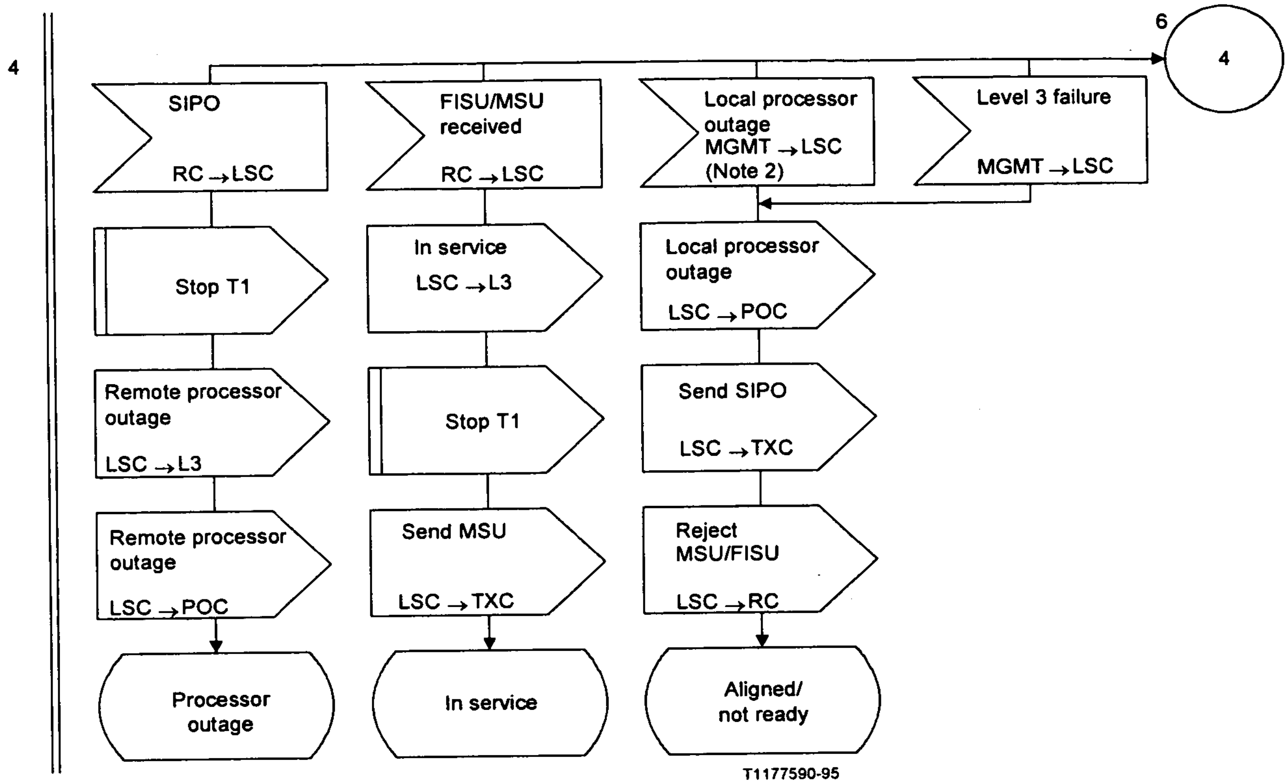


Figure 8/Q.703 (sheet 7 of 14) – Link state control

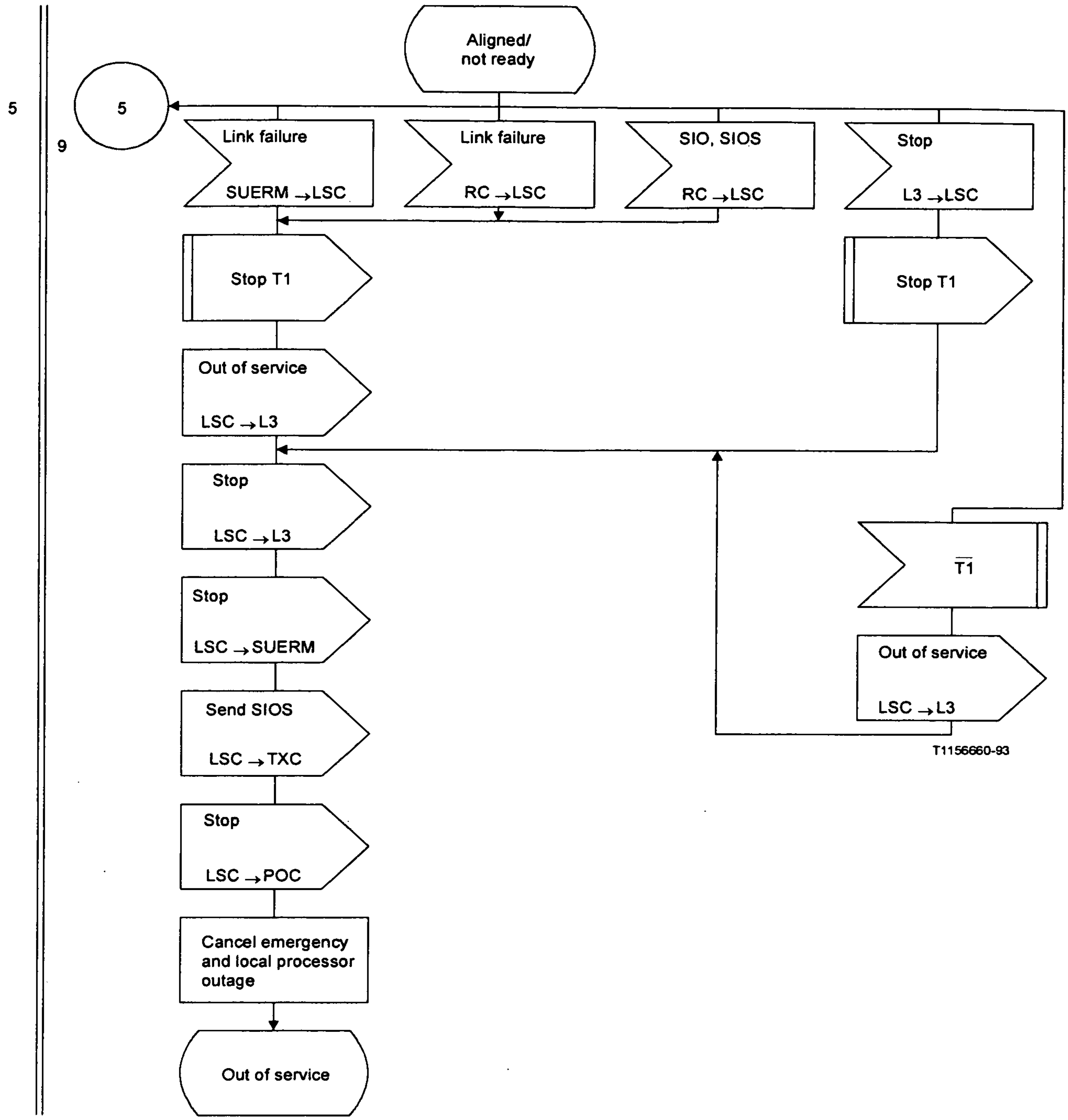


Figure 8/Q.703 (sheet 8 of 14) – Link state control

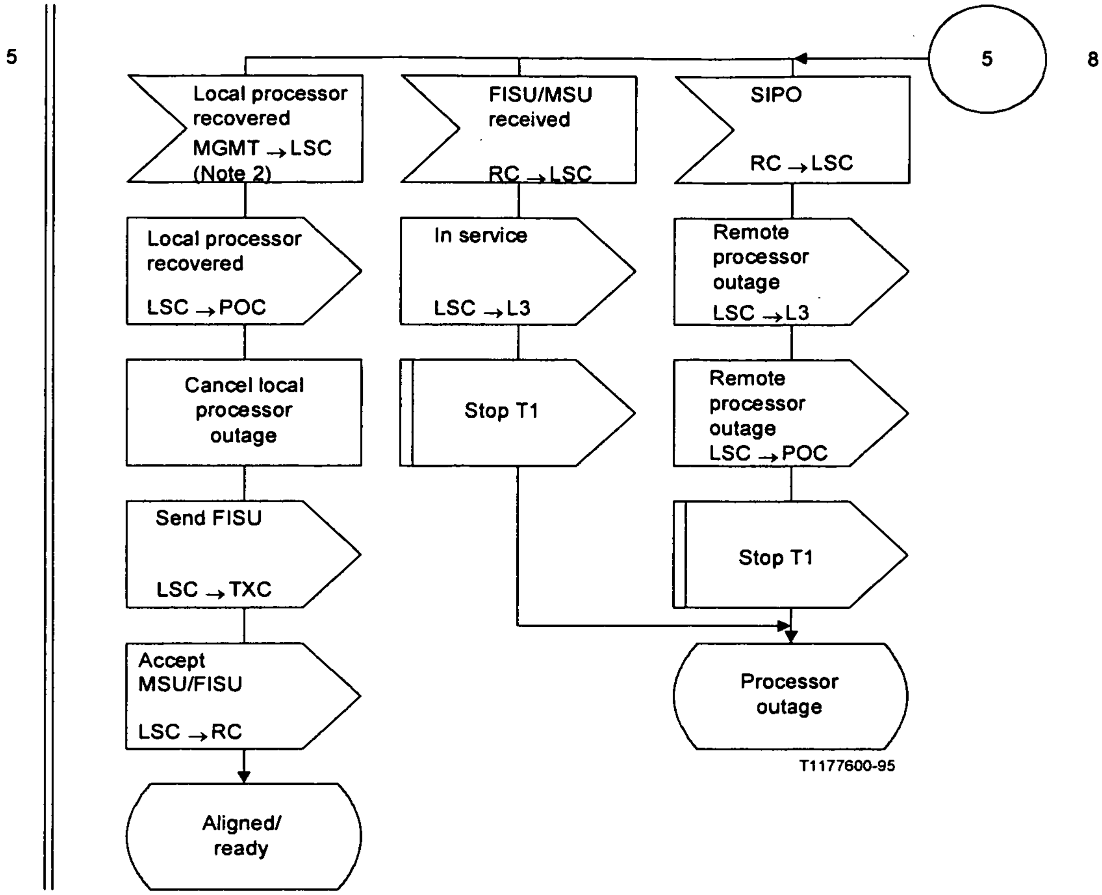


Figure 8/Q.703 (sheet 9 of 14) – Link state control

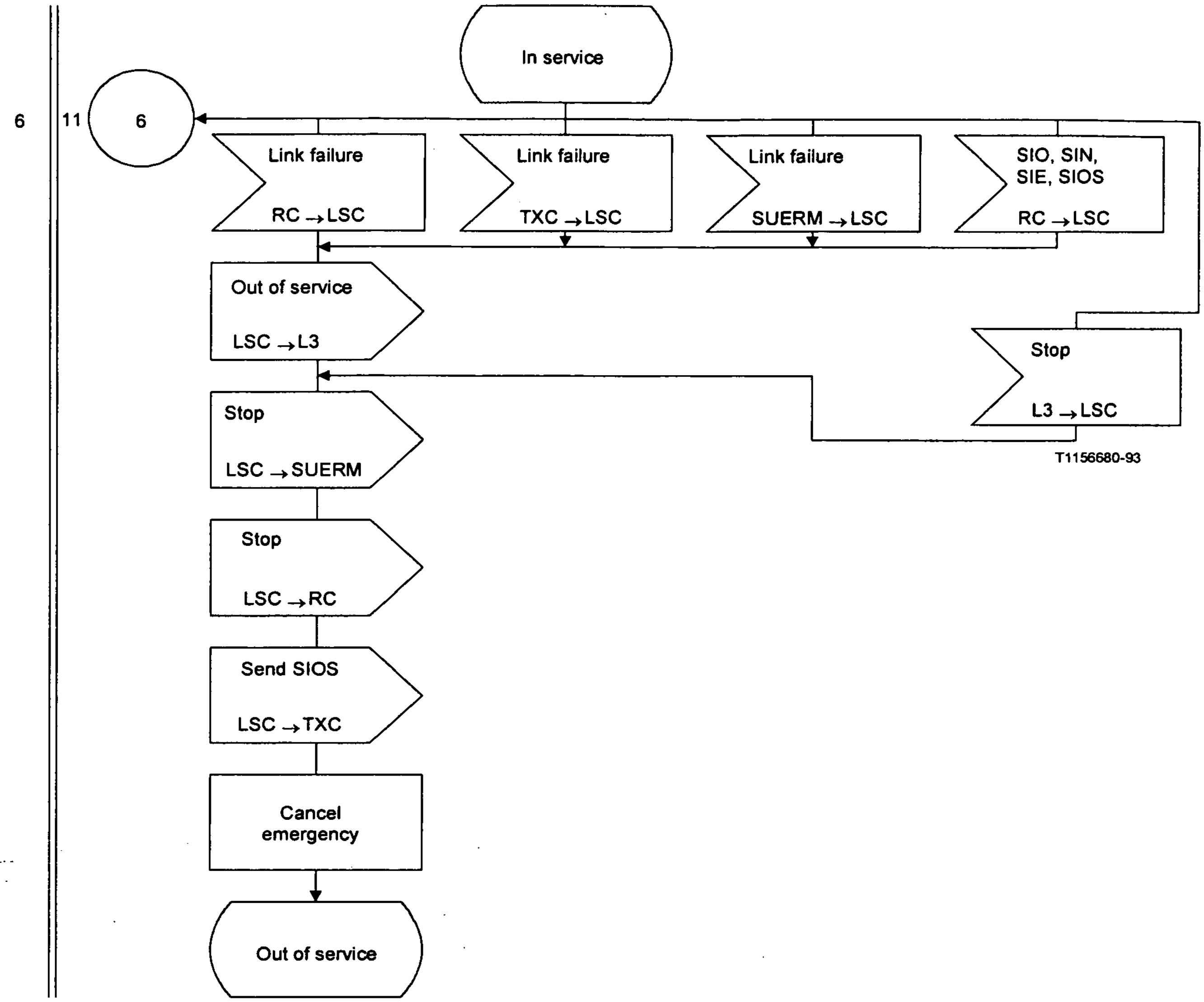


Figure 8/Q.703 (sheet 10 of 14) – Link state control

6

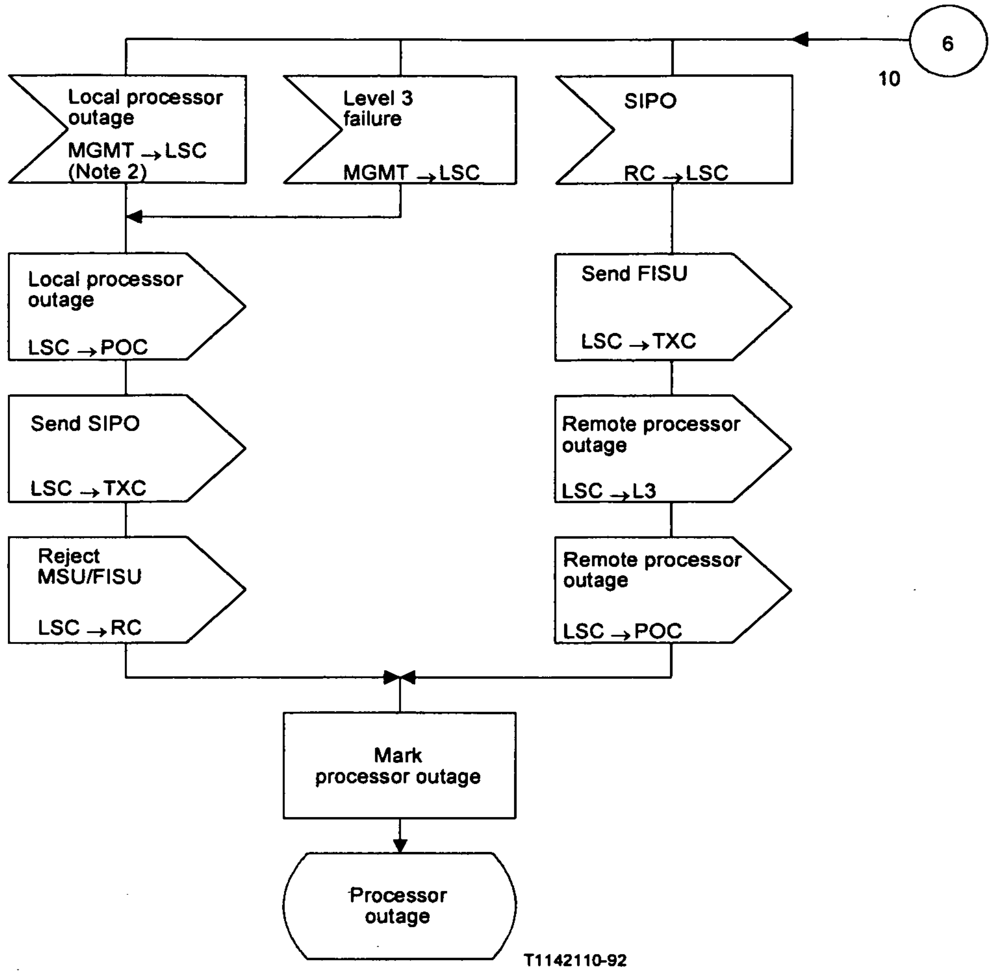


Figure 8/Q.703 (sheet 11 of 14) – Link state control

7

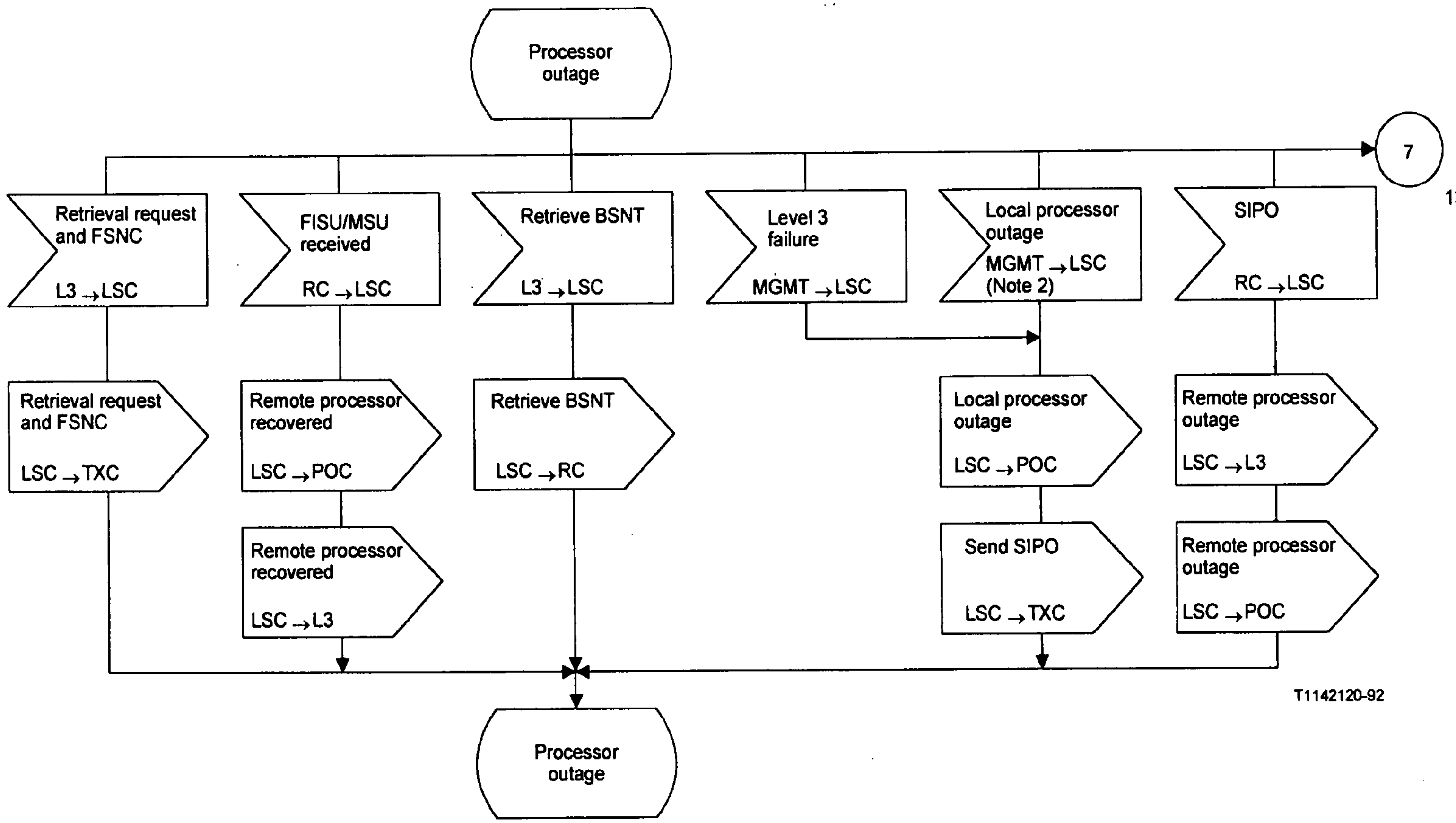


Figure 8/Q.702 (sheet 12 of 14) – Link state control

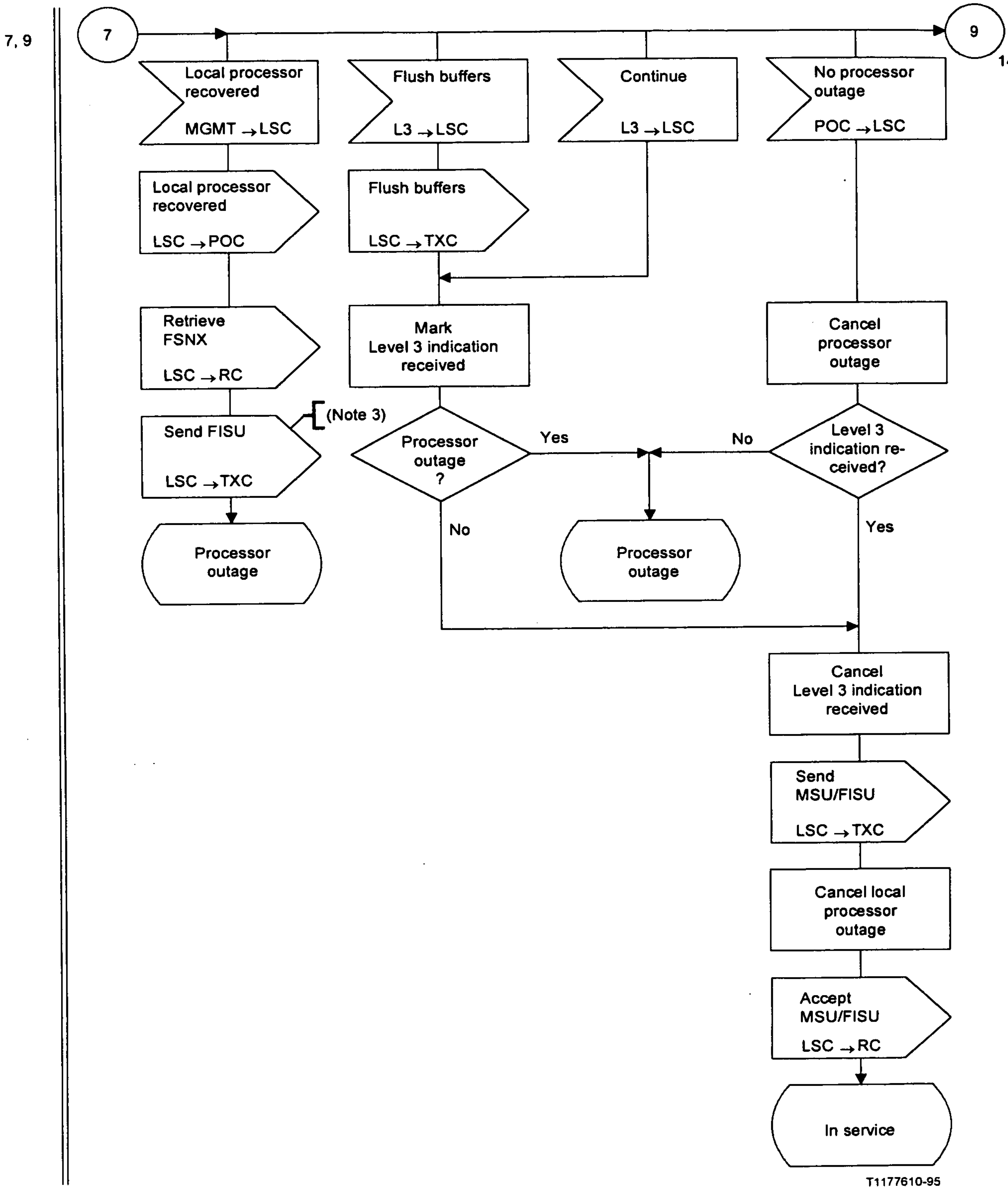
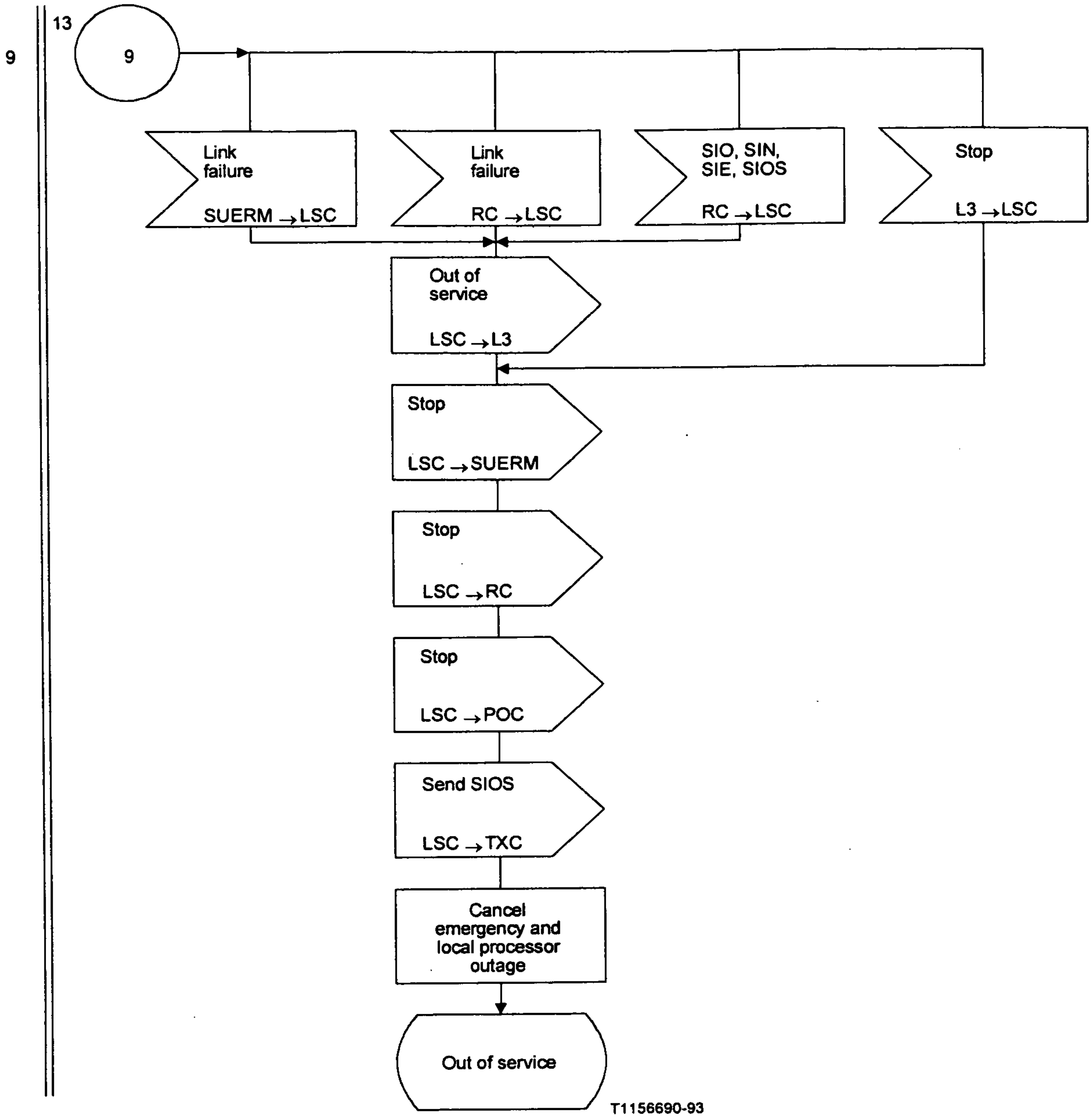


Figure 8/Q.703 (sheet 13 of 14) – Link state control



NOTES

1 – See the abbreviations and timers used in this Figure in 12.2.

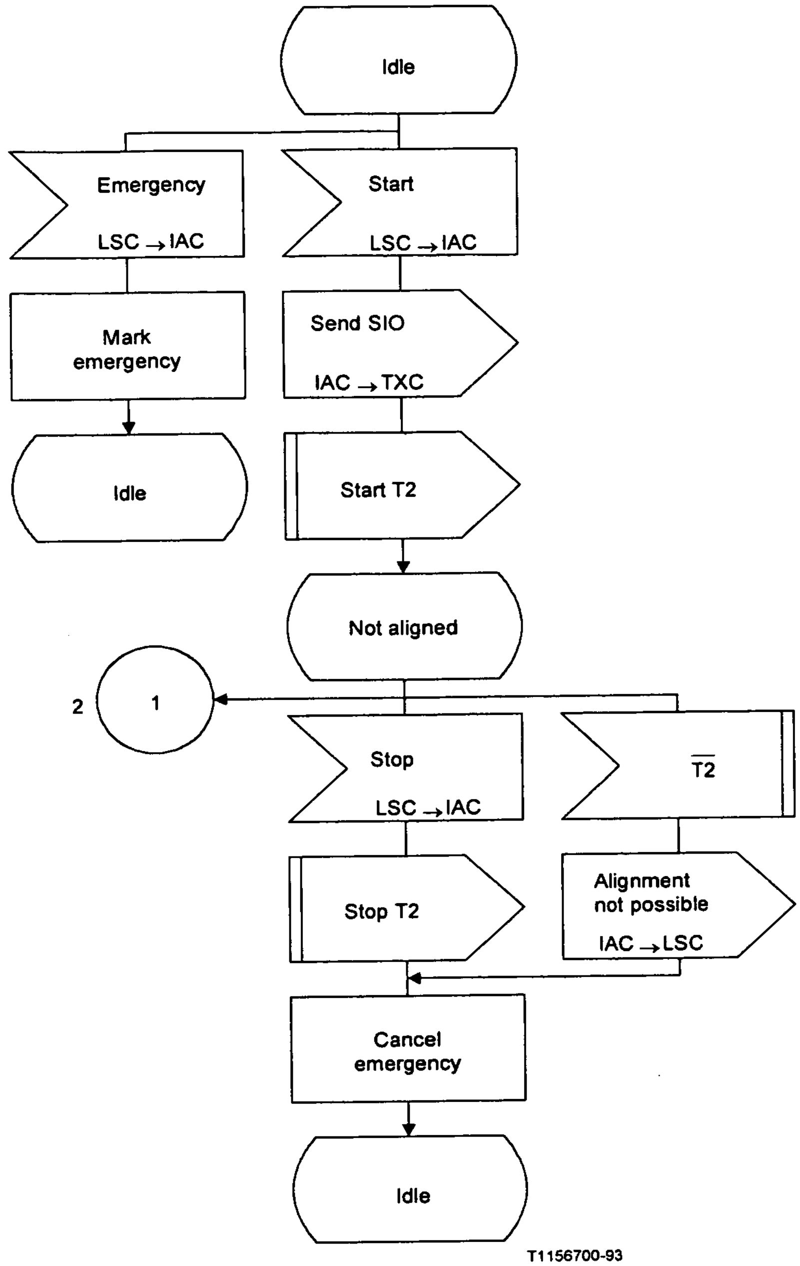
2 – For the national option of latching of processor outage, the input "Local processor outage" can also come from "L3".

3 – For a correct synchronization of the sequence numbers at the remote side, the BSN within the FISU must be BSN:=FSNX-1.

4 – Alternatively, the flushing of buffers and synchronization of sequence numbers may be replaced by taking the signalling link out of service. In addition, this would cater for *Blue Book* level 3 and the present version level 2 interworking.

Figure 8/Q.703 (sheet 14 of 14) – Link state control

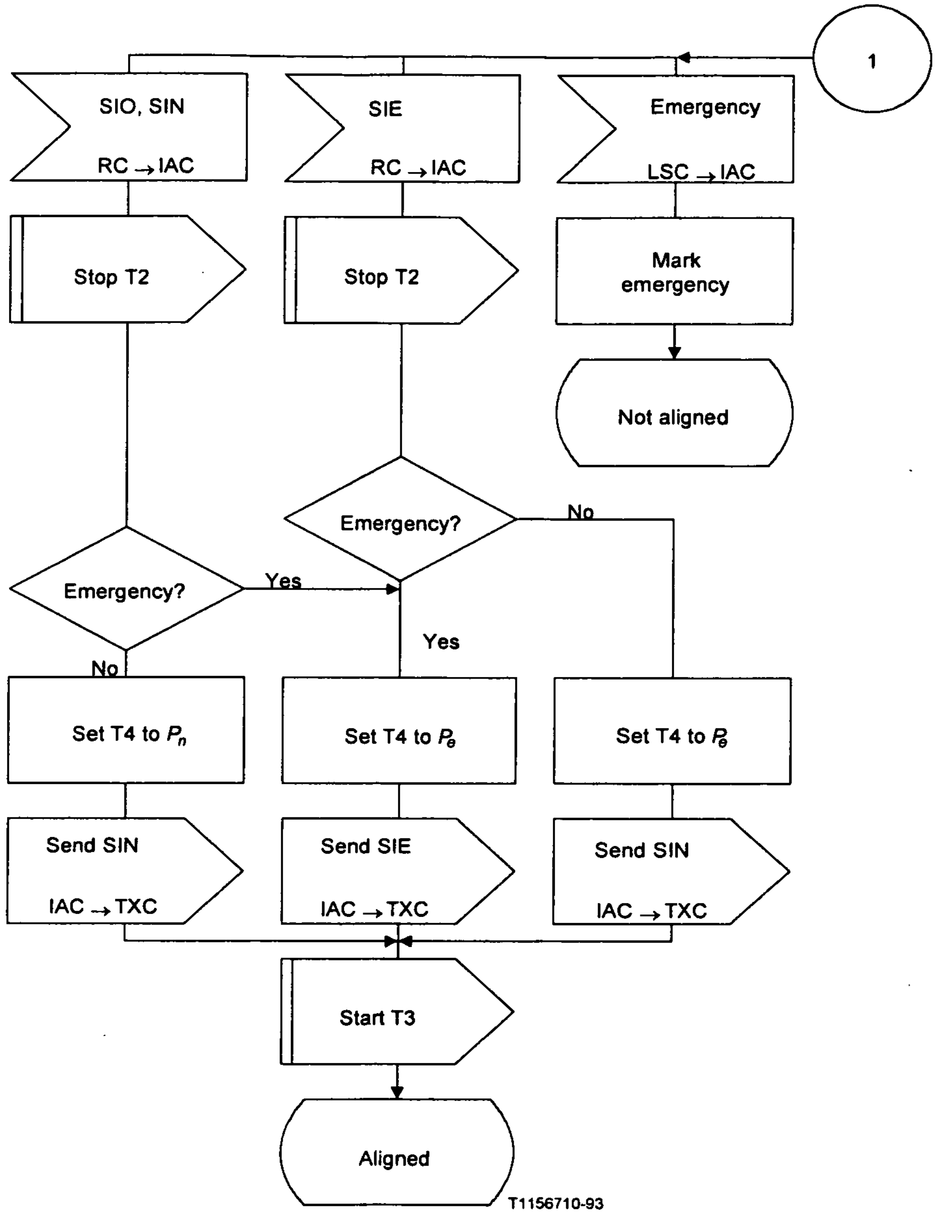
1



NOTE – See the abbreviations and timers used in this Figure in 12.2.

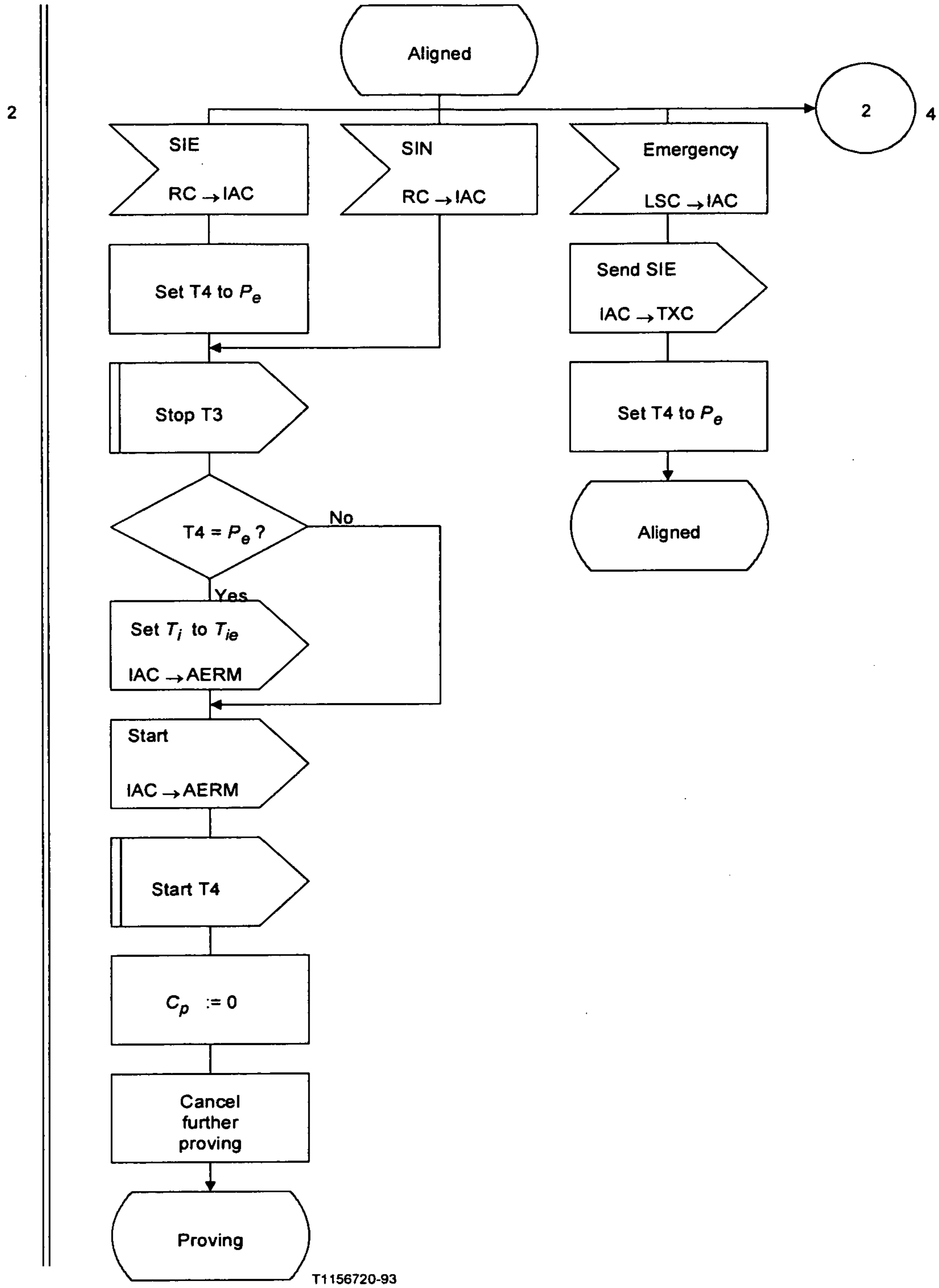
Figure 9/Q.703 (sheet 1 of 6) – Initial alignment control

1



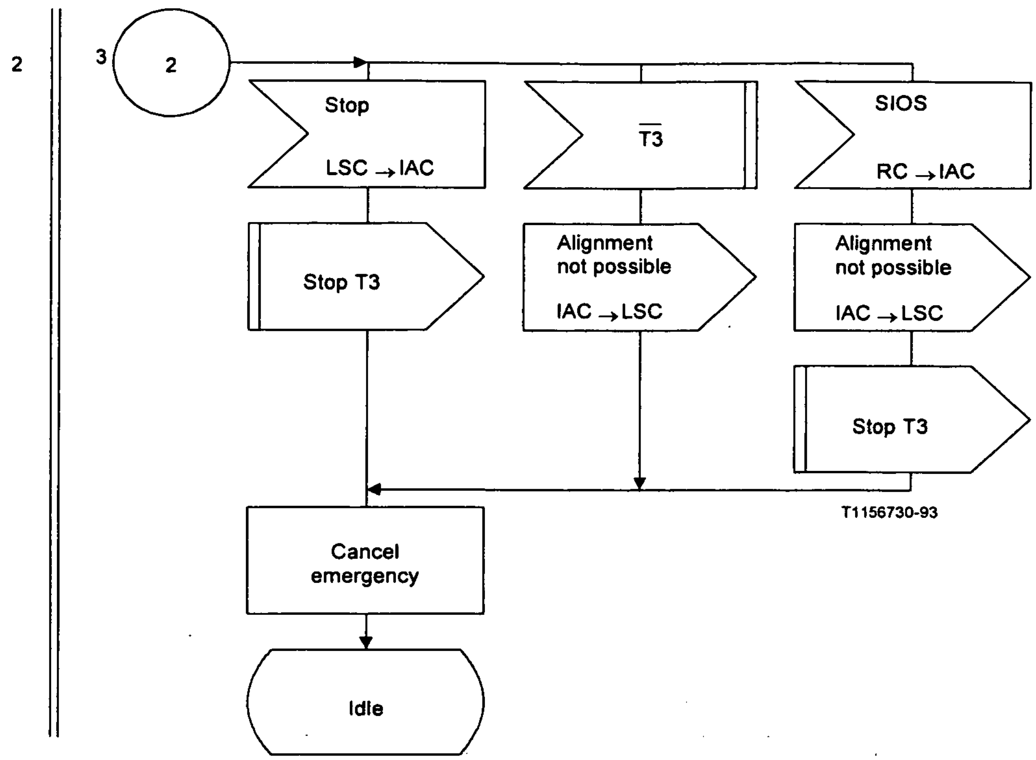
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 9/Q.703 (sheet 2 of 6) – Initial alignment control



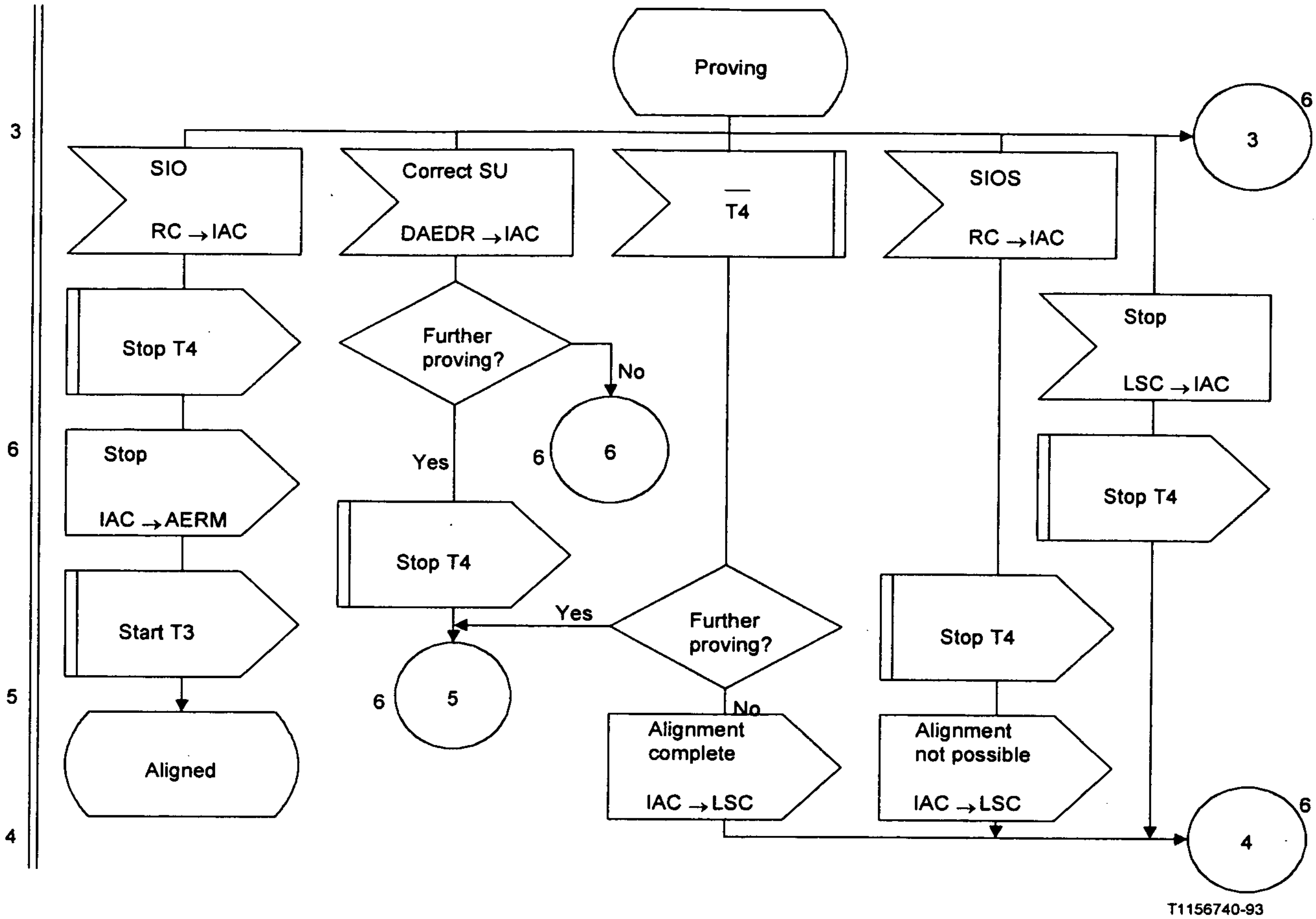
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 9/Q.703 (sheet 3 of 6) – Initial alignment control



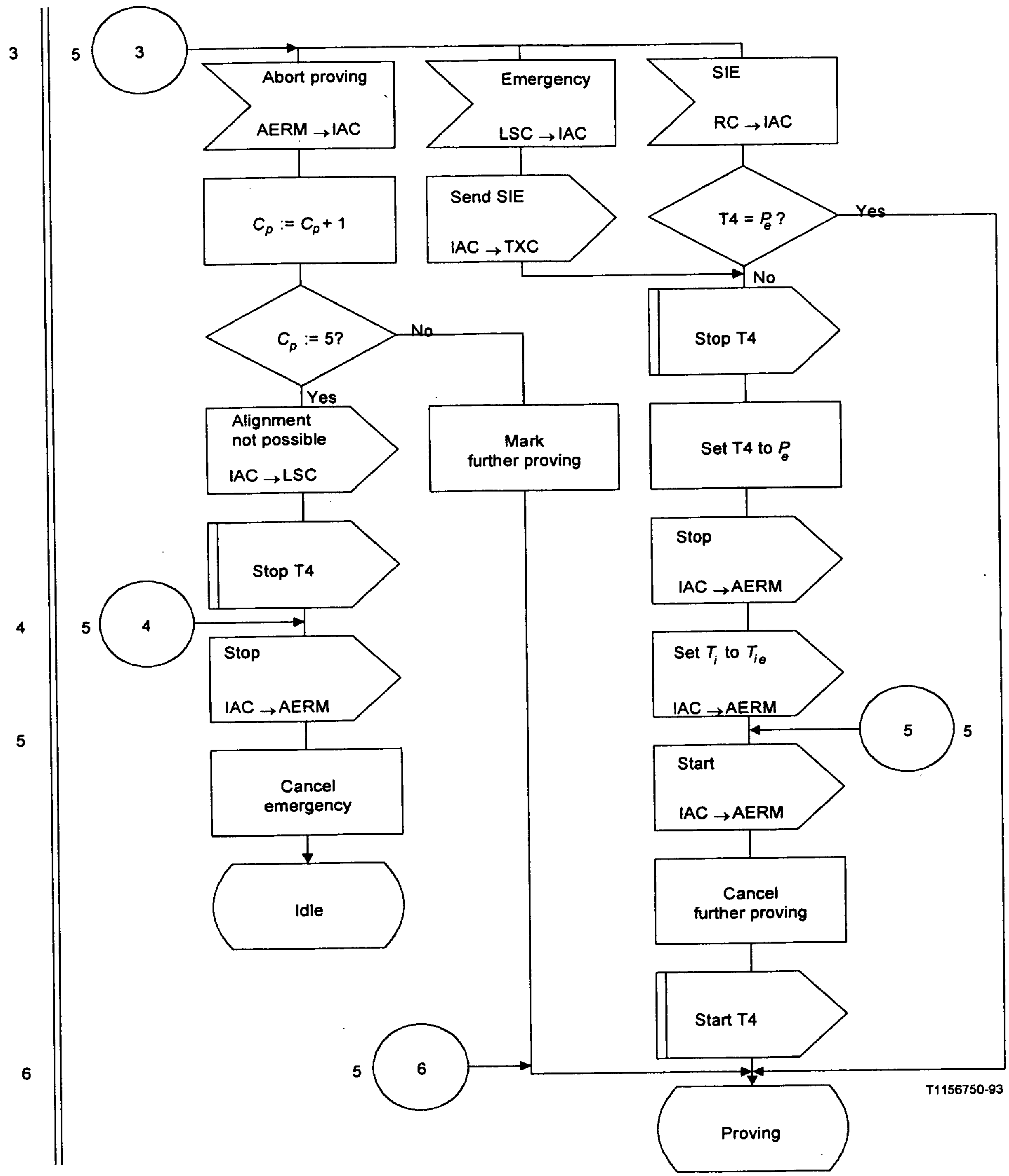
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 9/Q.703 (sheet 4 of 6) – Initial alignment control



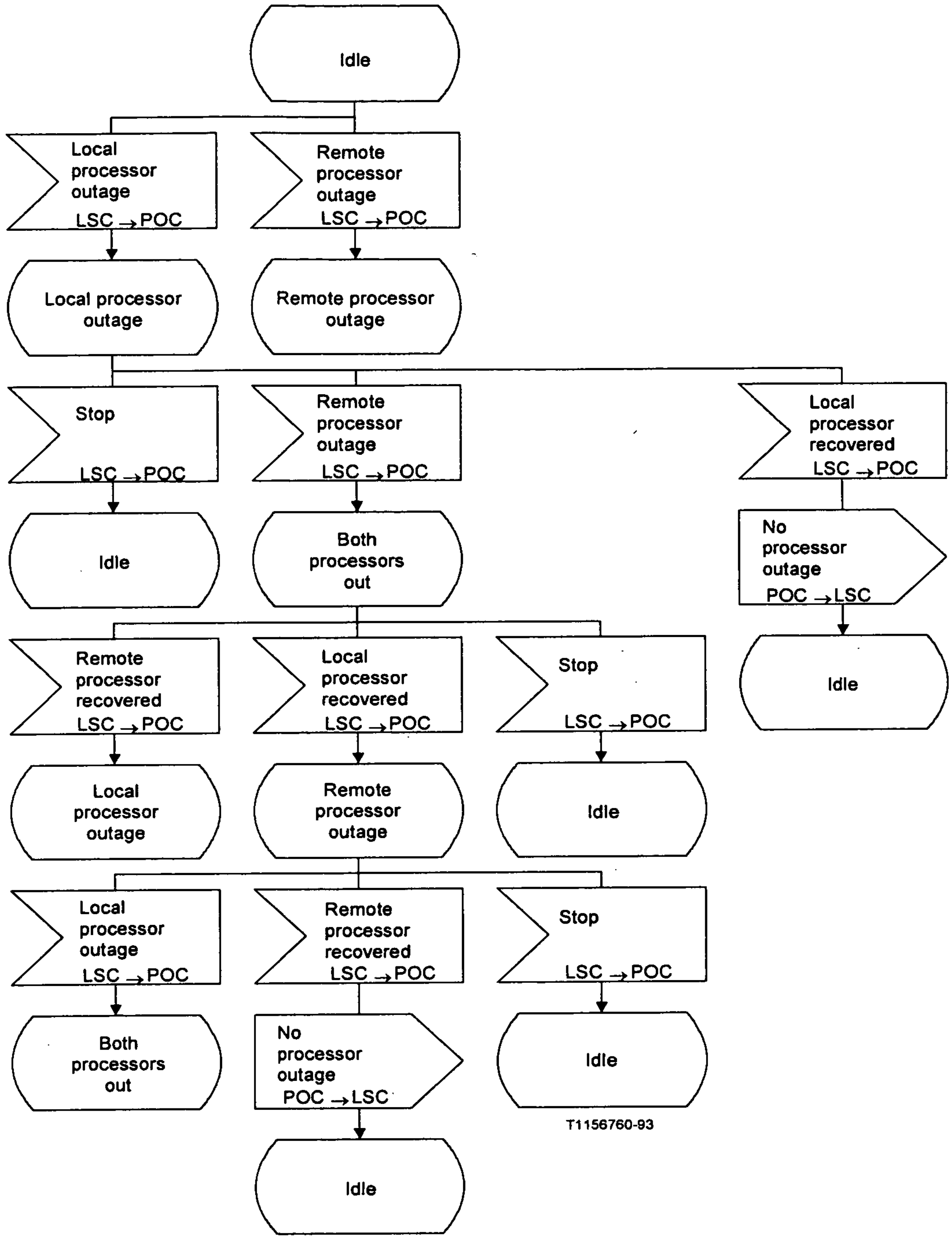
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 9/Q.703 (sheet 5 of 6) – Initial alignment control



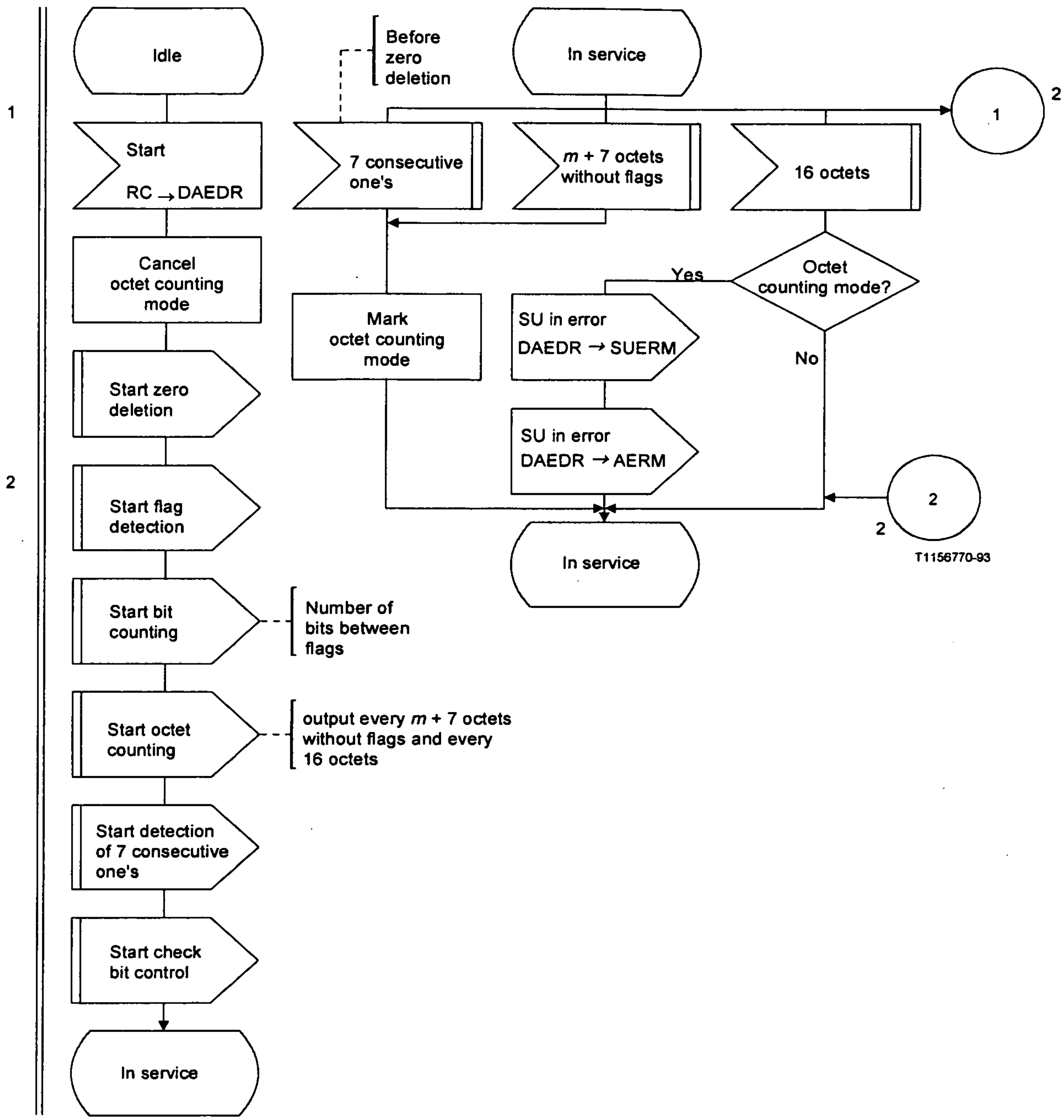
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 9/Q.703 (sheet 6 of 6) – Initial alignment control



NOTE – See the abbreviations and timers used in this Figure in 12.2.

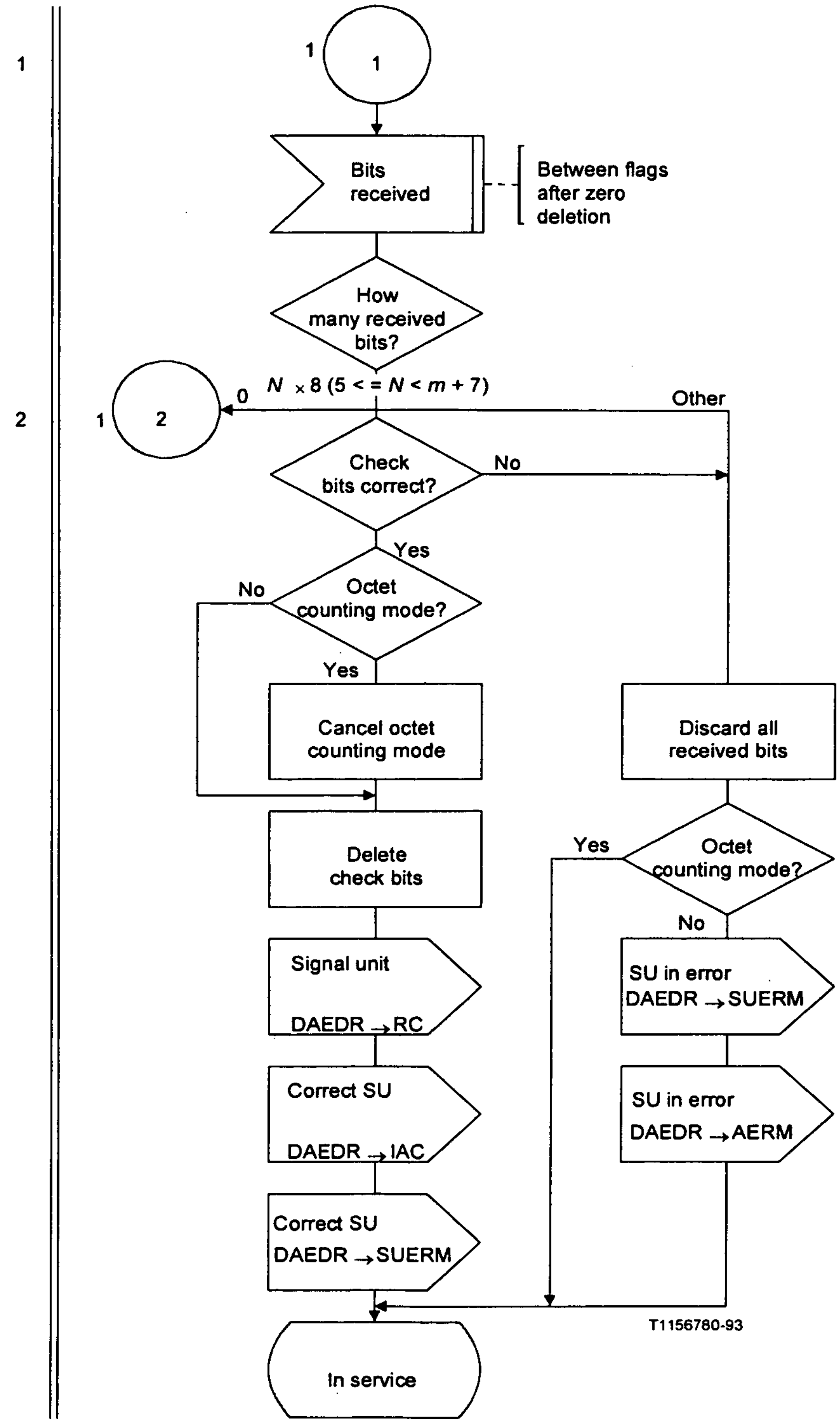
Figure 10/Q.703 – Processor outage control



m Maximum length in octet of SIF permitted on this signalling link

NOTE – See the abbreviations and timers used in this Figure in 12.2.

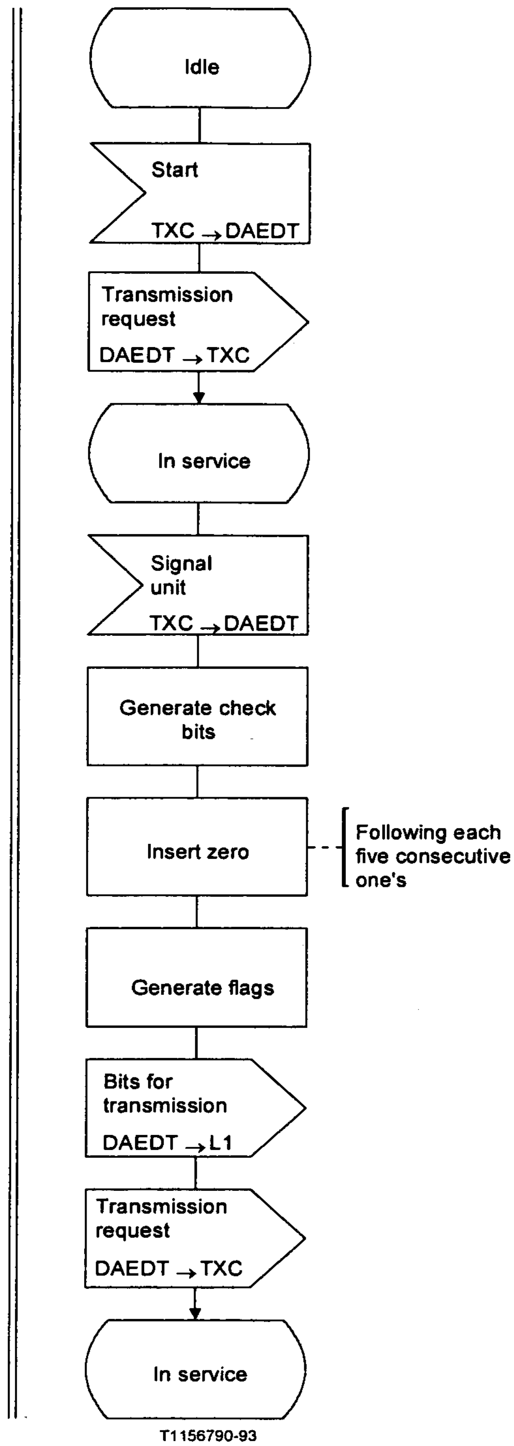
Figure 11/Q.703 (sheet 1 of 2) – Delimitation, alignment and error detection (receiving)



N Number of octets received between flags

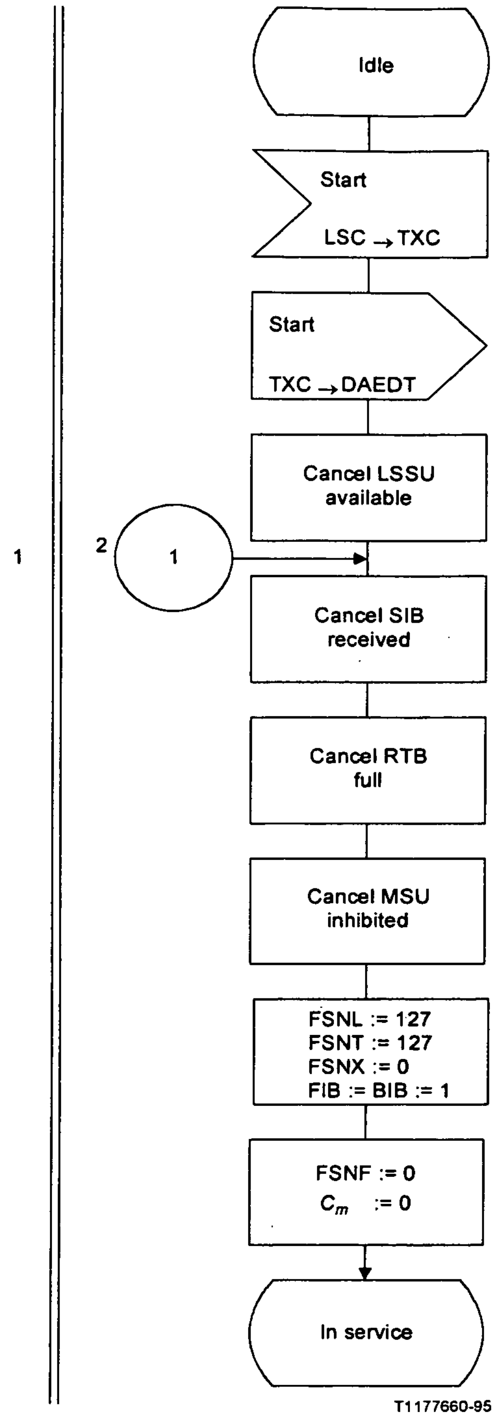
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 11/Q.703 (sheet 2 of 2) – Delimitation, alignment and error detection (receiving)



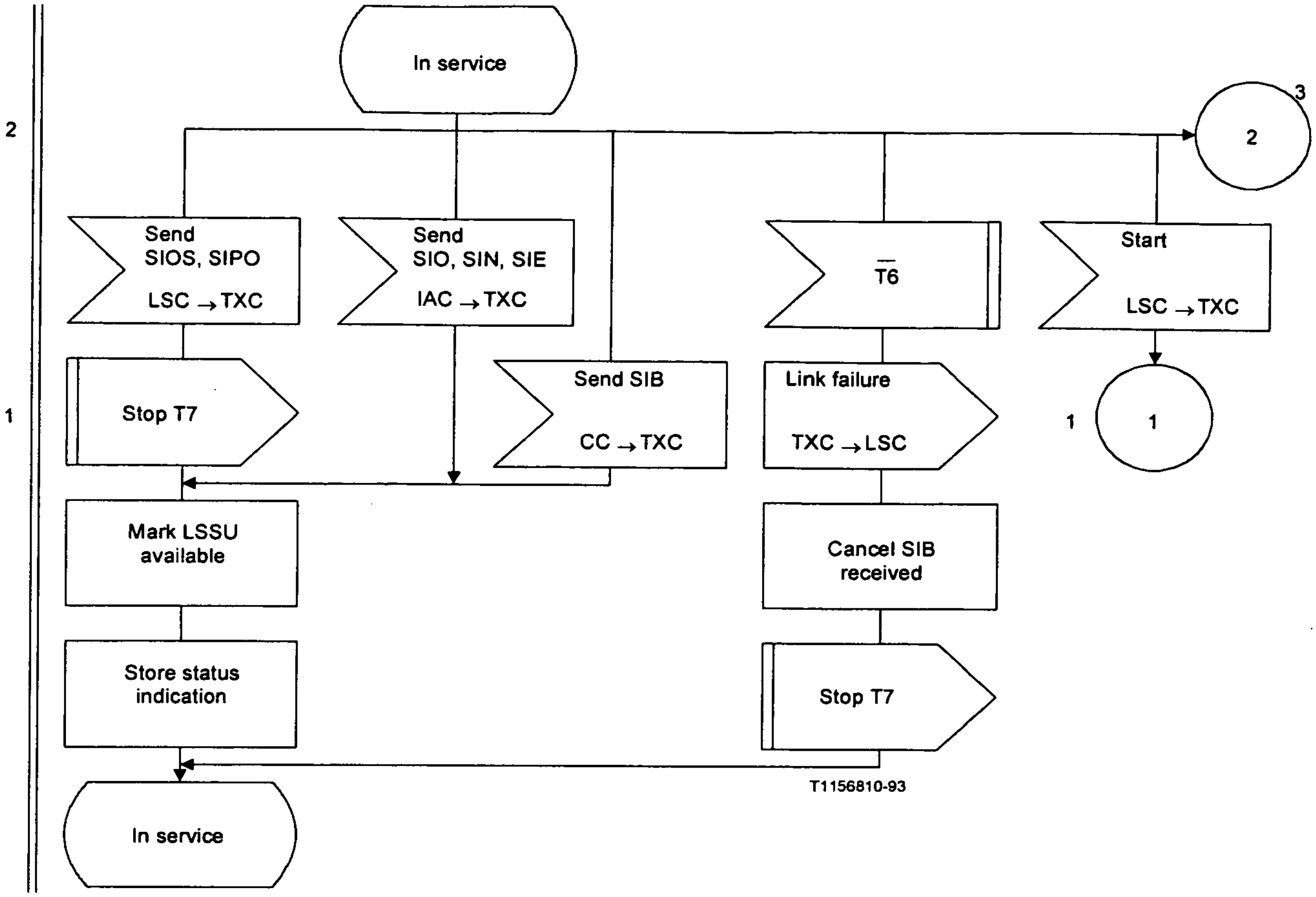
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 12/Q.703 – Delimitation, alignment and error detection (transmitting)



NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 13/Q.703 (sheet 1 of 7) – Basic transmission control



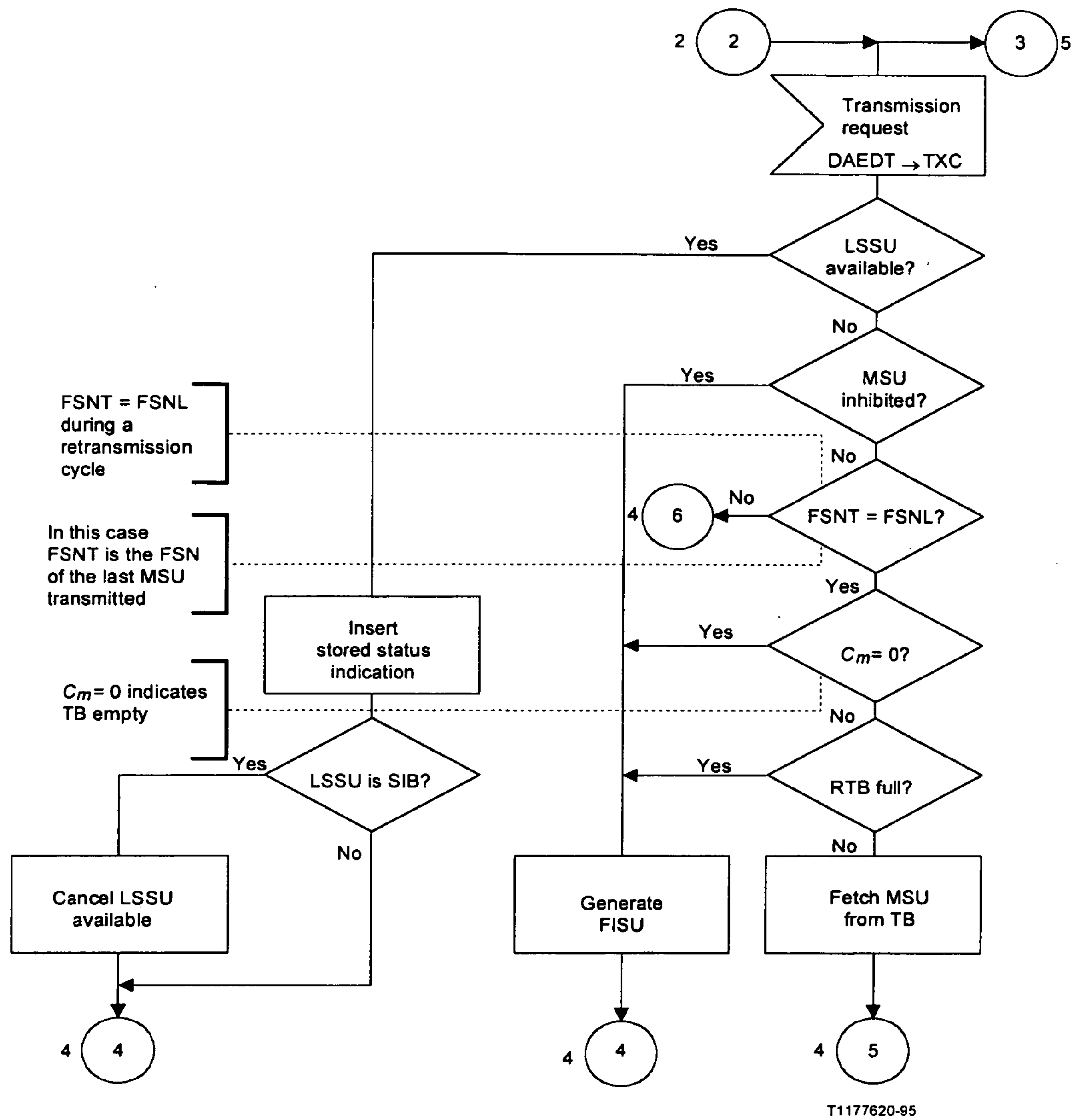
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 13/Q.703 (sheet 2 of 7) – Basic transmission control

3, 2

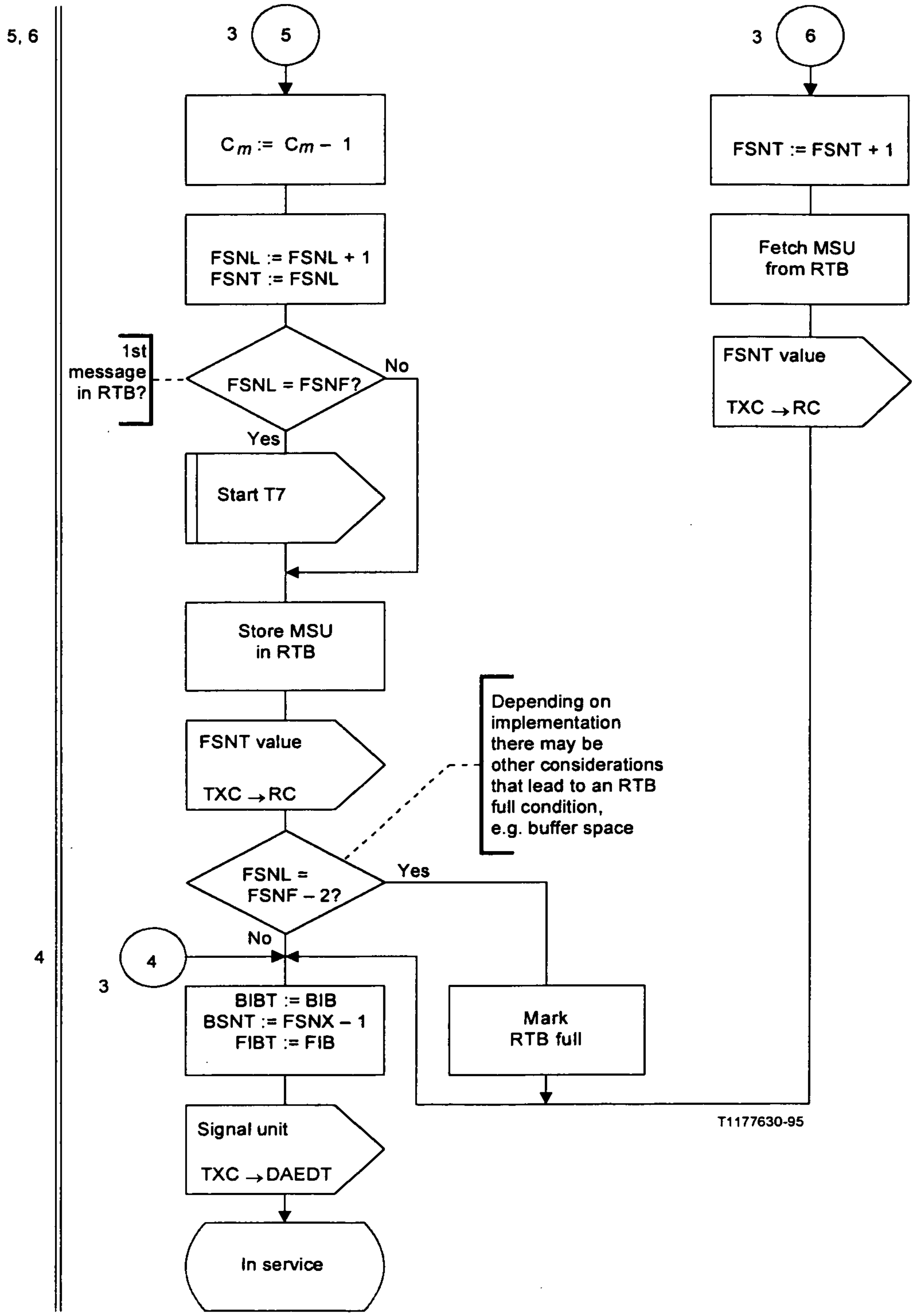
6

4, 5



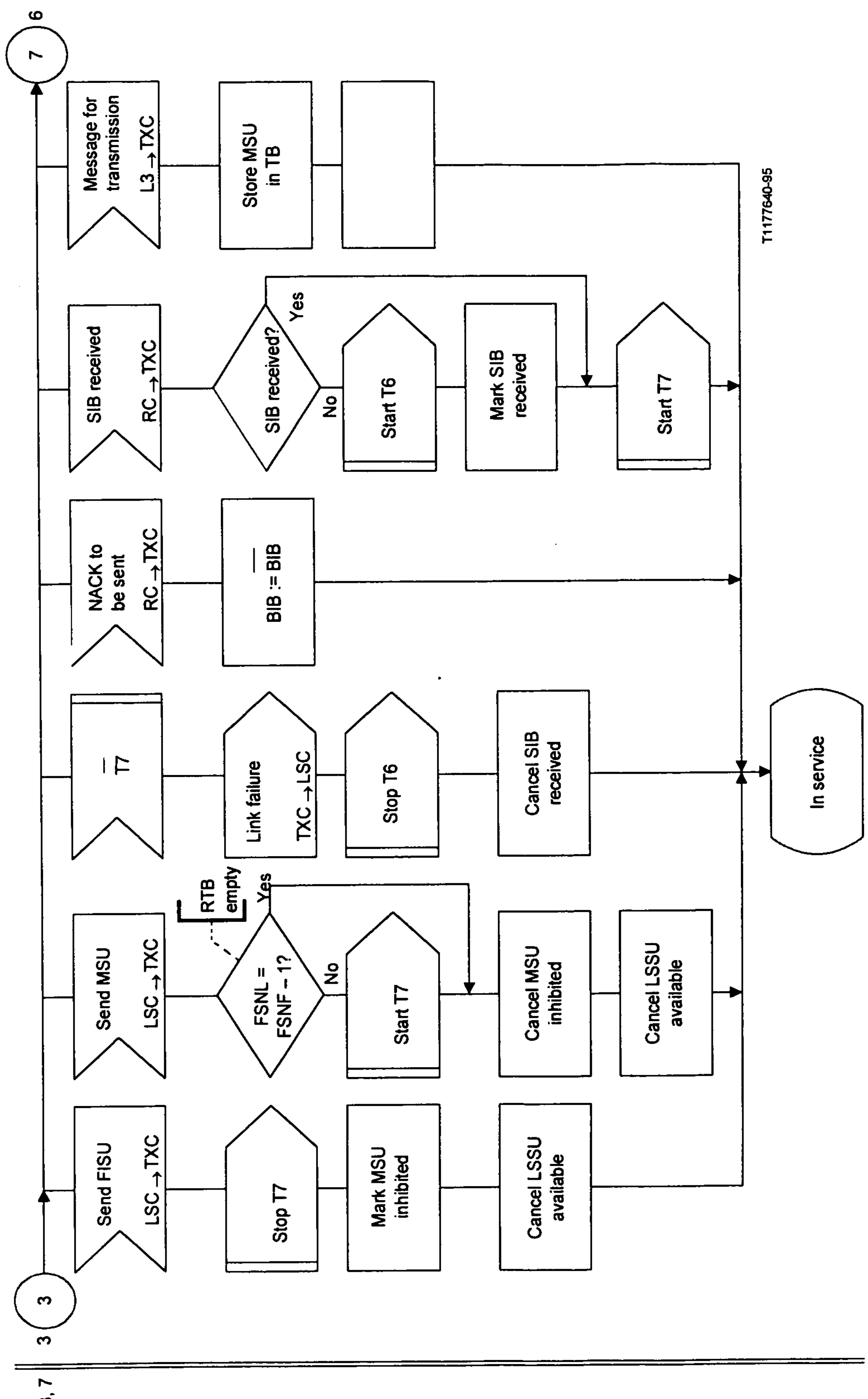
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 13/Q.703 (sheet 3 of 7) – Basic transmission control



NOTE – See the abbreviations and timers used in this Figure in 12.2.

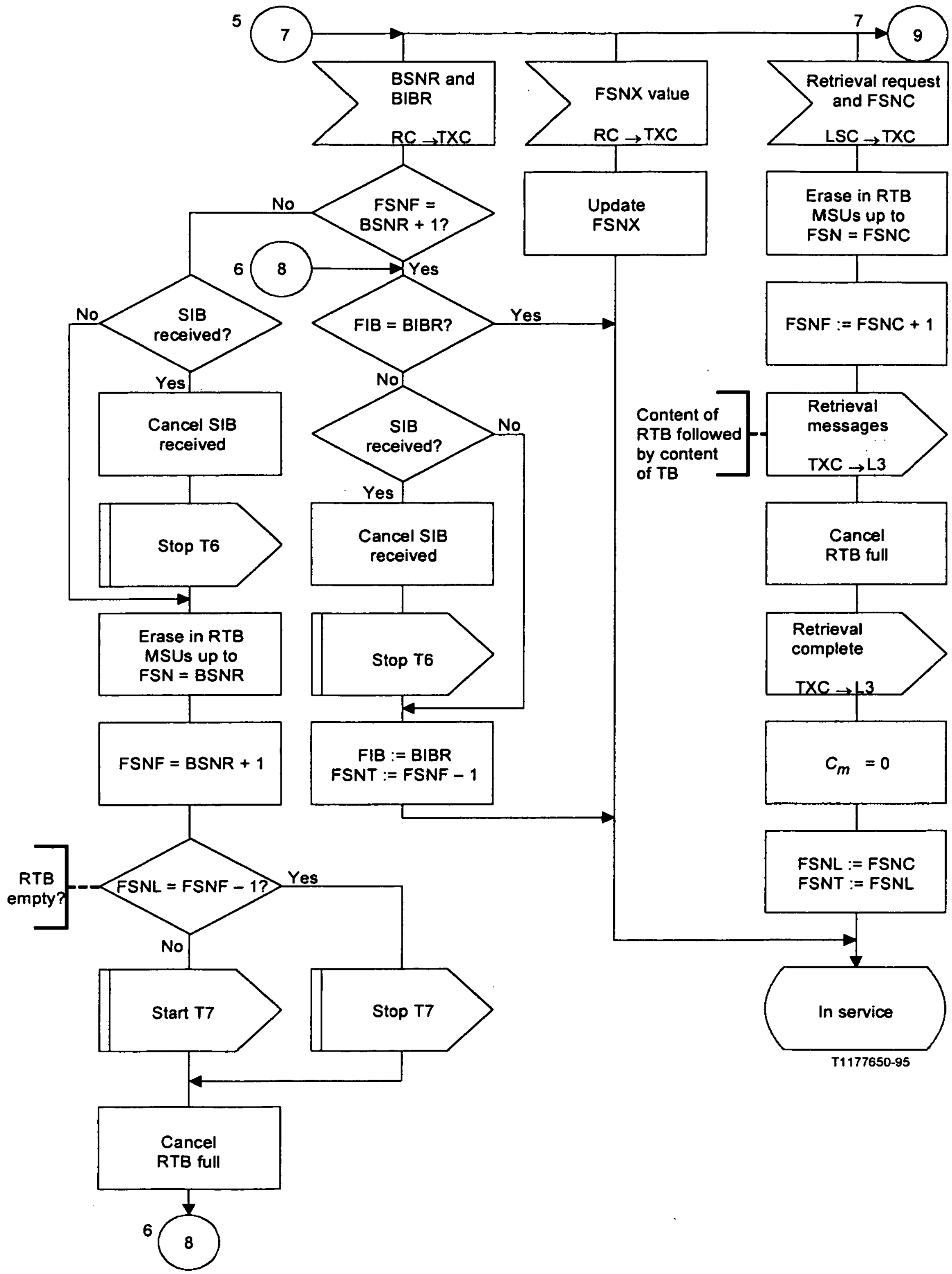
Figure 13/Q.703 (sheet 4 of 7) – Basic transmission control



NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 13/Q.703 (sheet 5 of 7) – Basic transmission control

7, 9

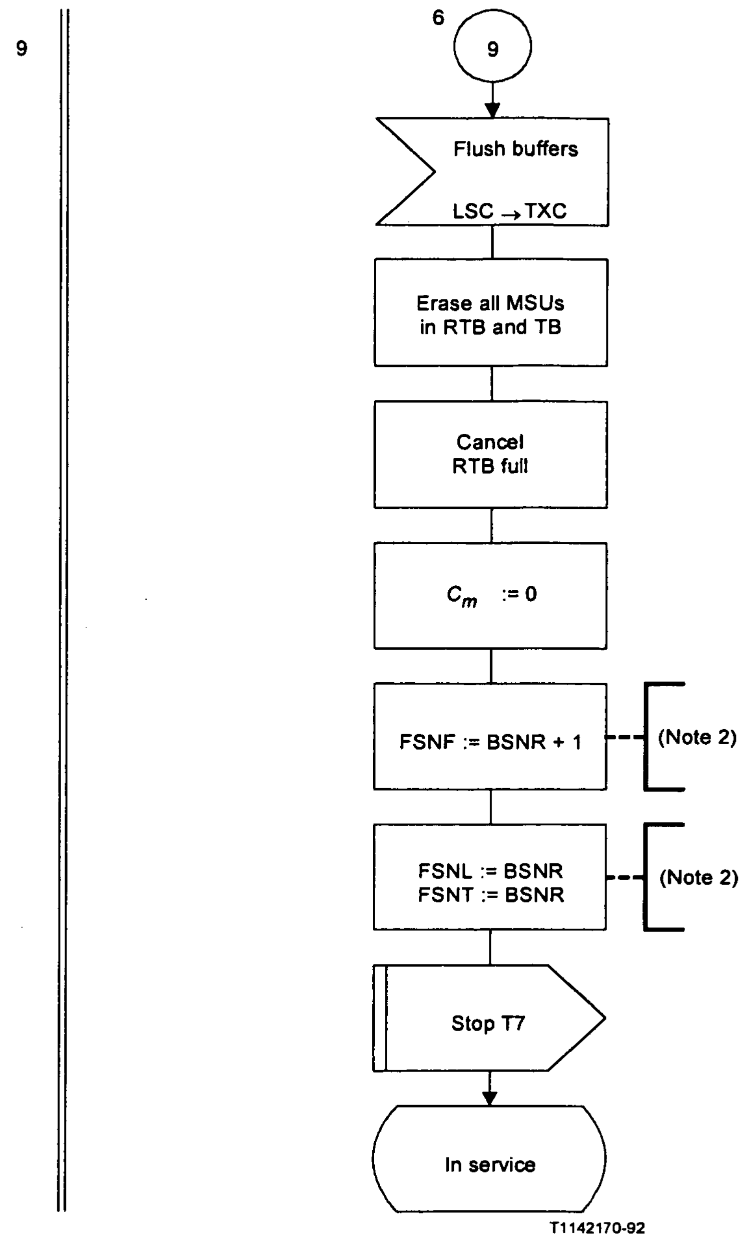


8

8

NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 13/Q.703 (sheet 6 of 7) – Basic transmission control

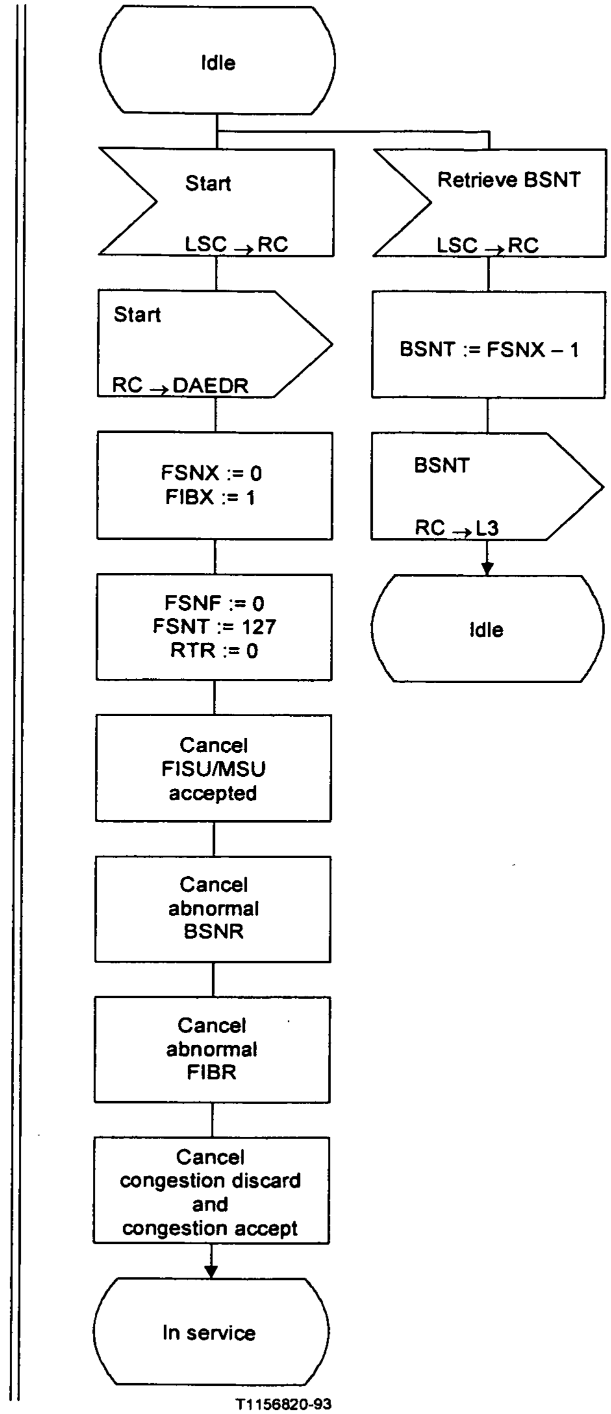


NOTES

1 – See the abbreviations and timers used in this Figure in 12.2.

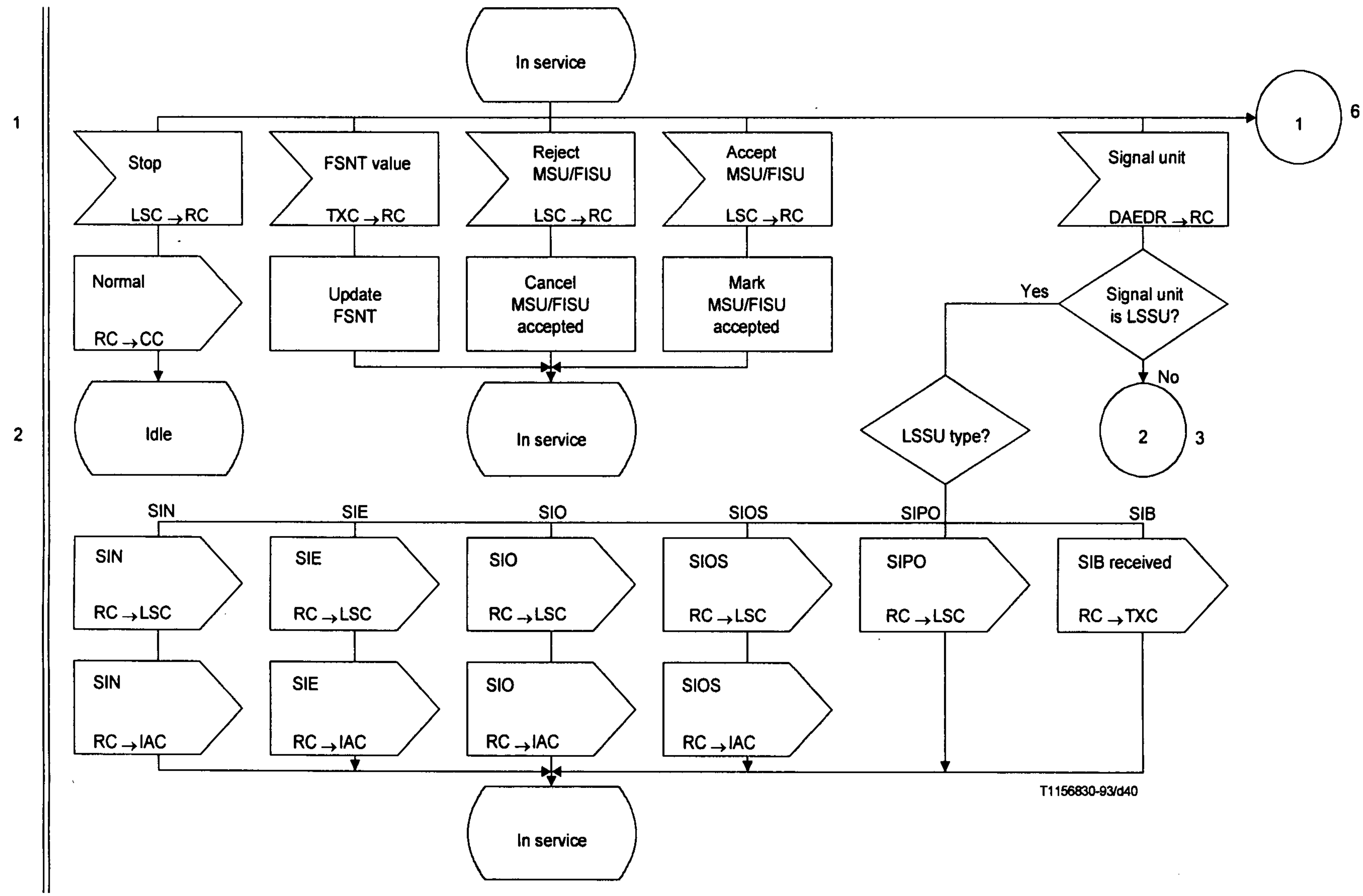
2 – The BSNR is from the first MSU/FSU terminating the remote processor outage state.

Figure 13/Q.703 (sheet 7 of 7) – Basic transmission control



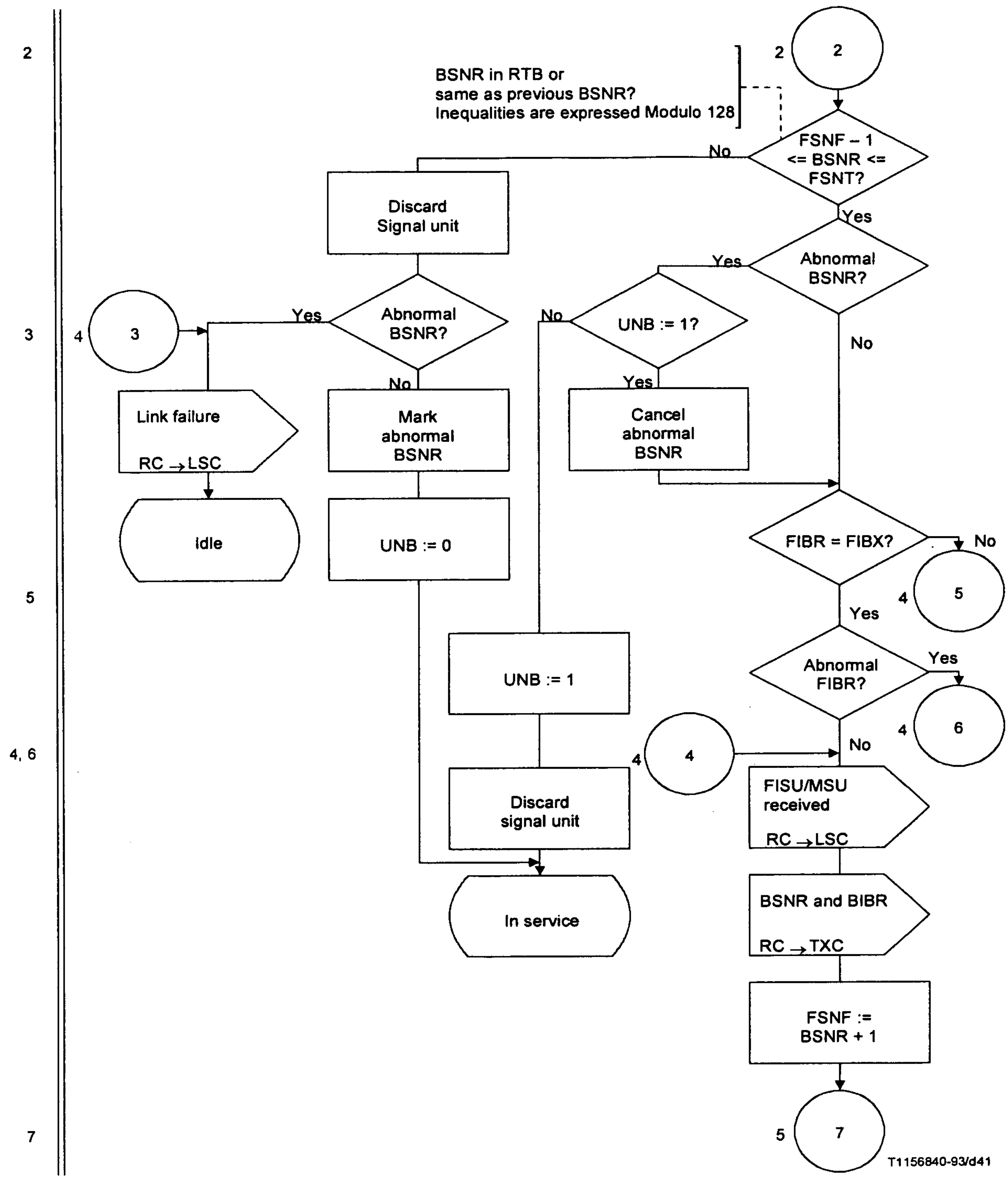
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 14/Q.703 (sheet 1 of 7) – Basic reception control



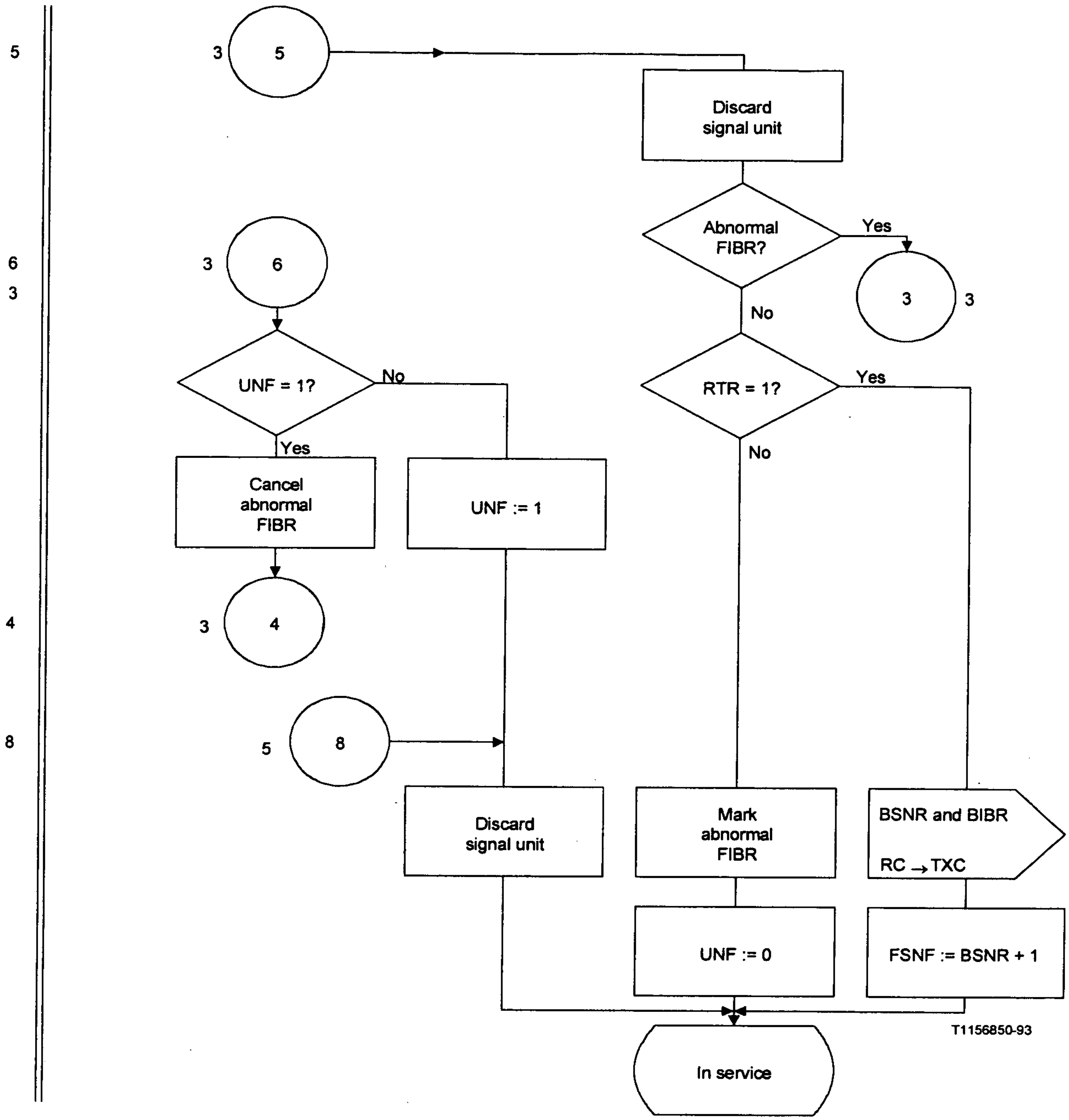
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 14/Q.703 (sheet 2 of 7) – Basic reception control



NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 14/Q.703 (sheet 3 of 7) – Basic reception control

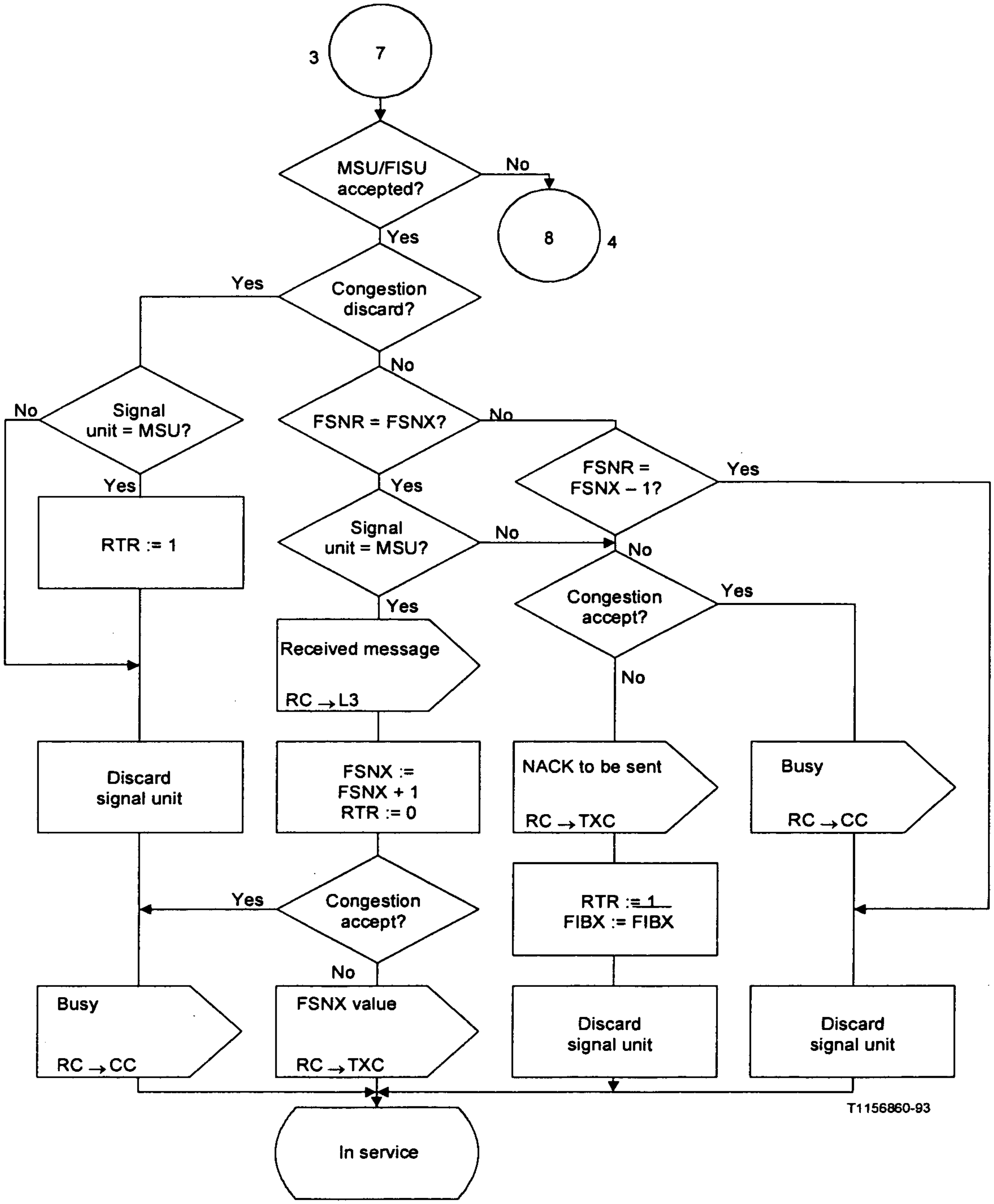


NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 14/Q.703 (sheet 4 of 7) – Basic reception control

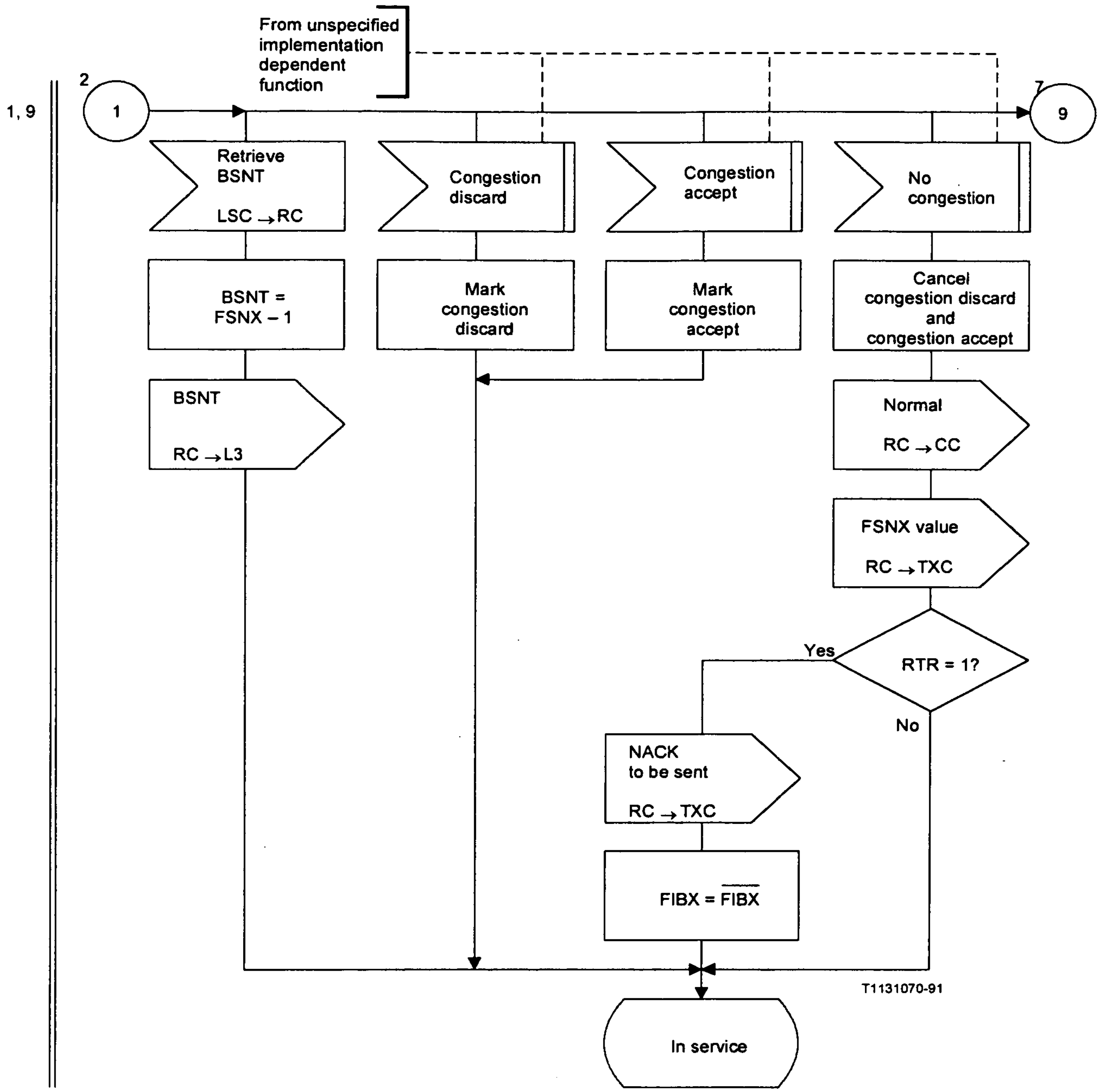
7

8



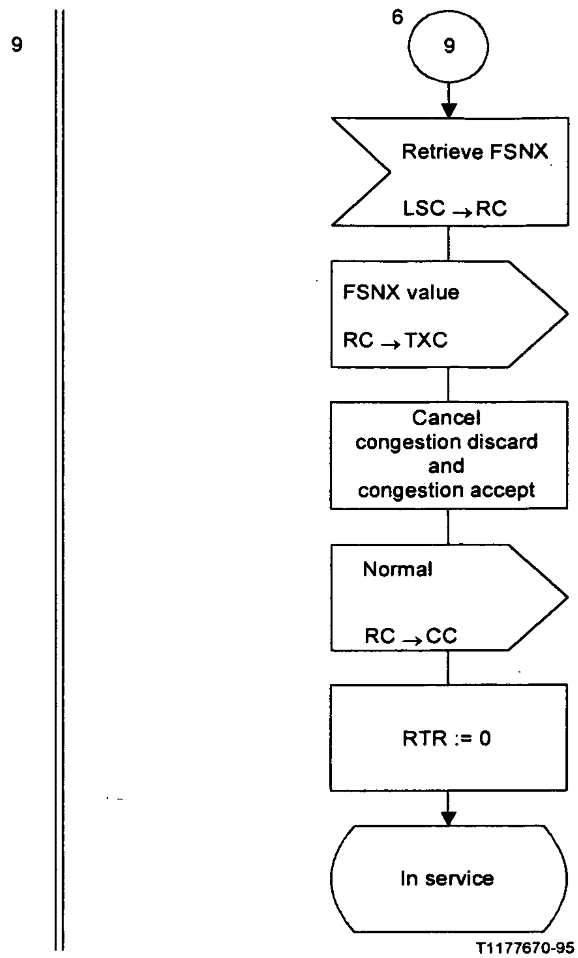
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 14/Q.703 (sheet 5 of 7) – Basic reception control



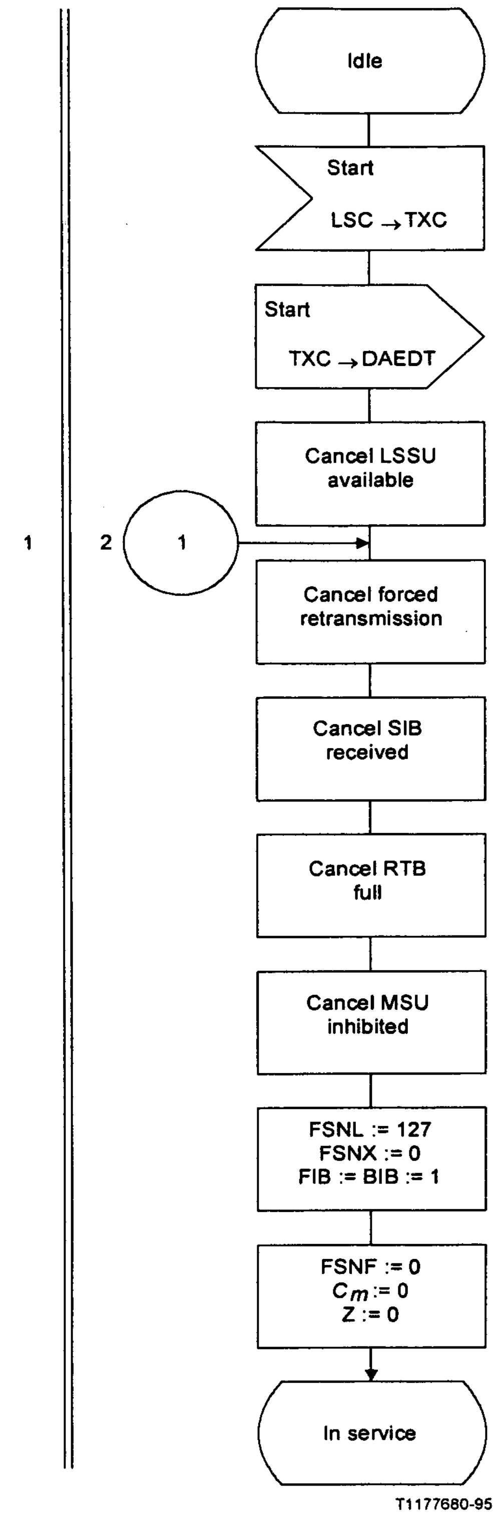
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 14/Q.703 (sheet 6 of 7) – Basic reception control



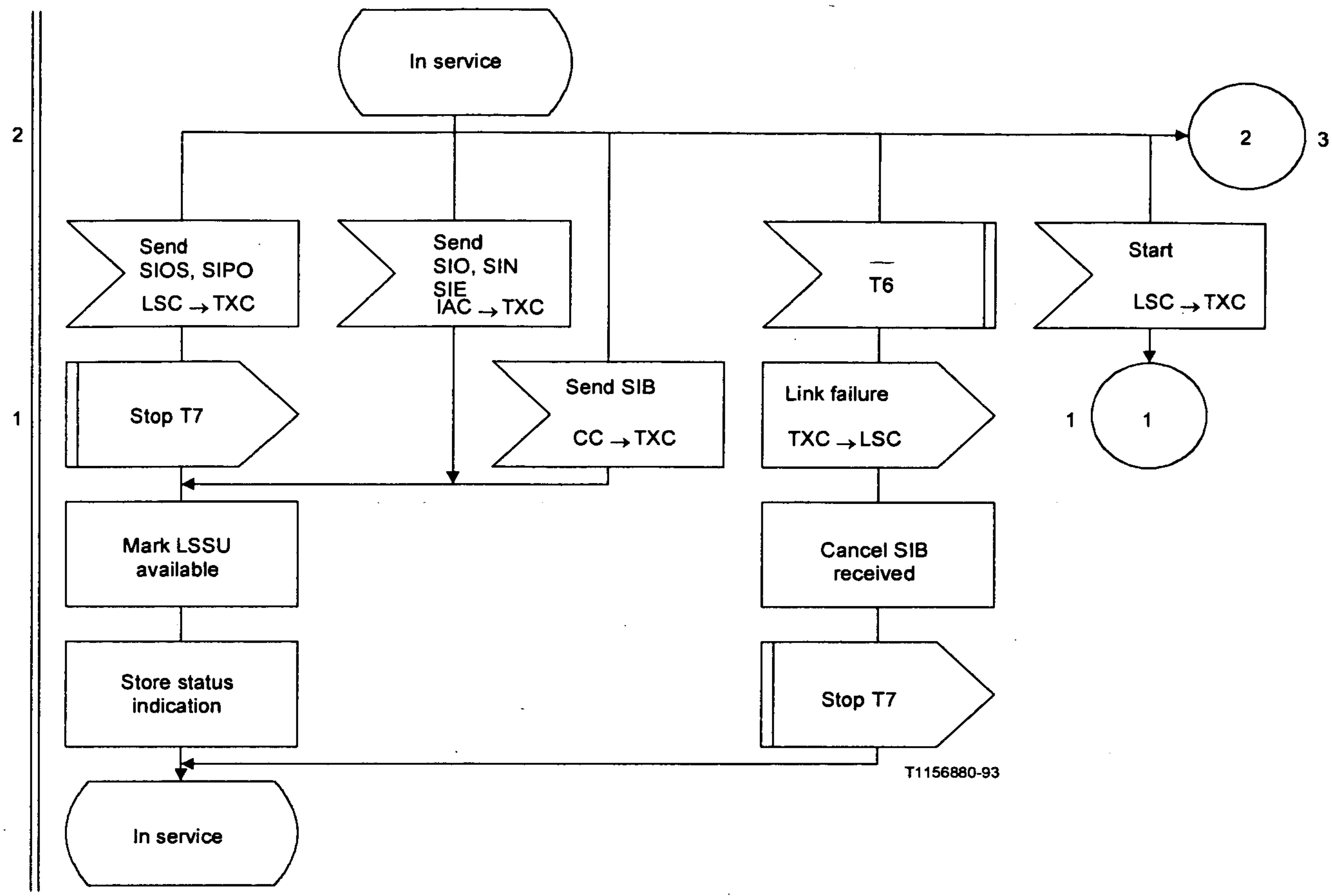
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 14/Q.703 (sheet 7 of 7) – Basic reception control



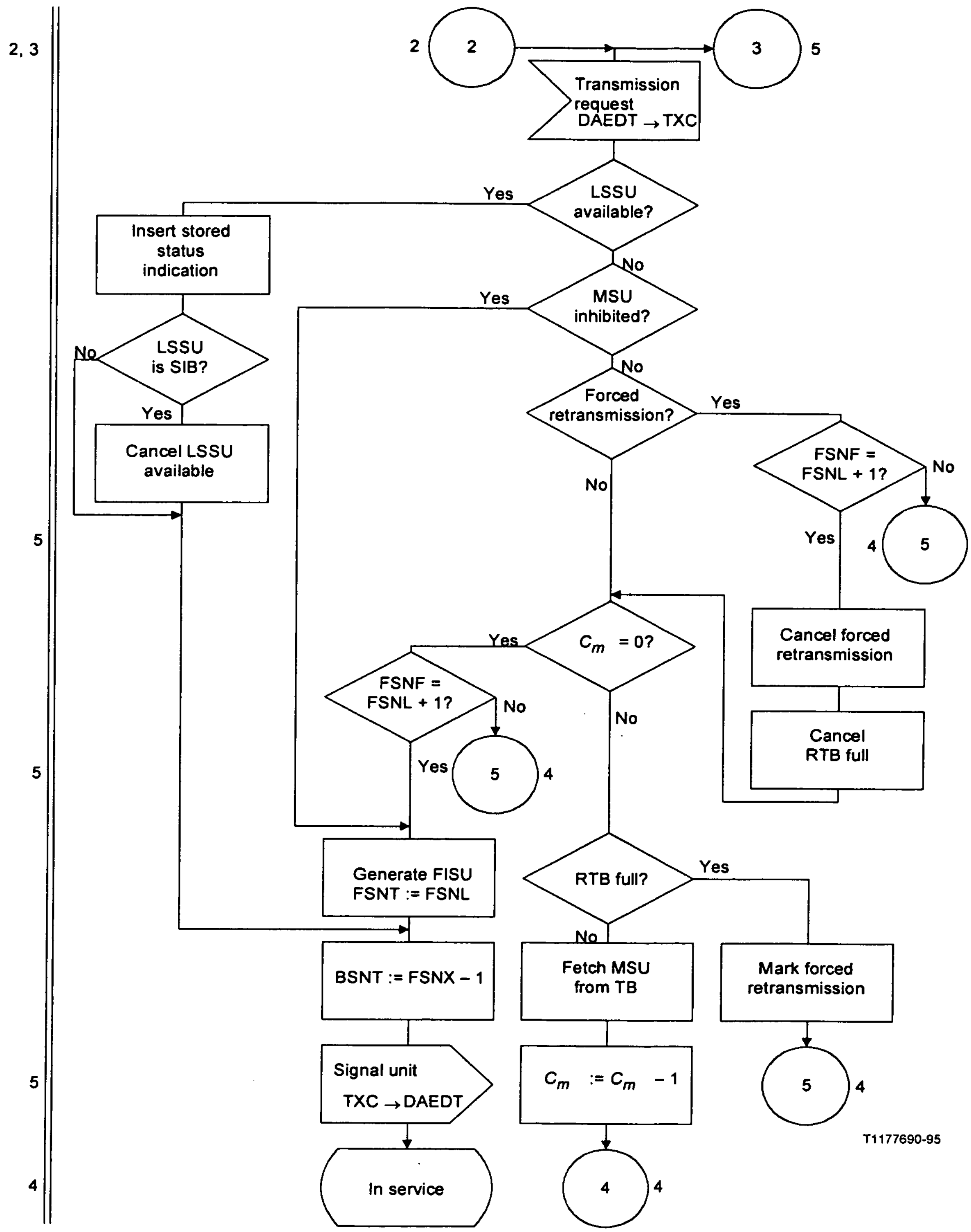
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 15/Q.703 (sheet 1 of 7) – Preventive cyclic retransmission – Transmission control



NOTE – See the abbreviations and timers used in this Figure in 12.2.

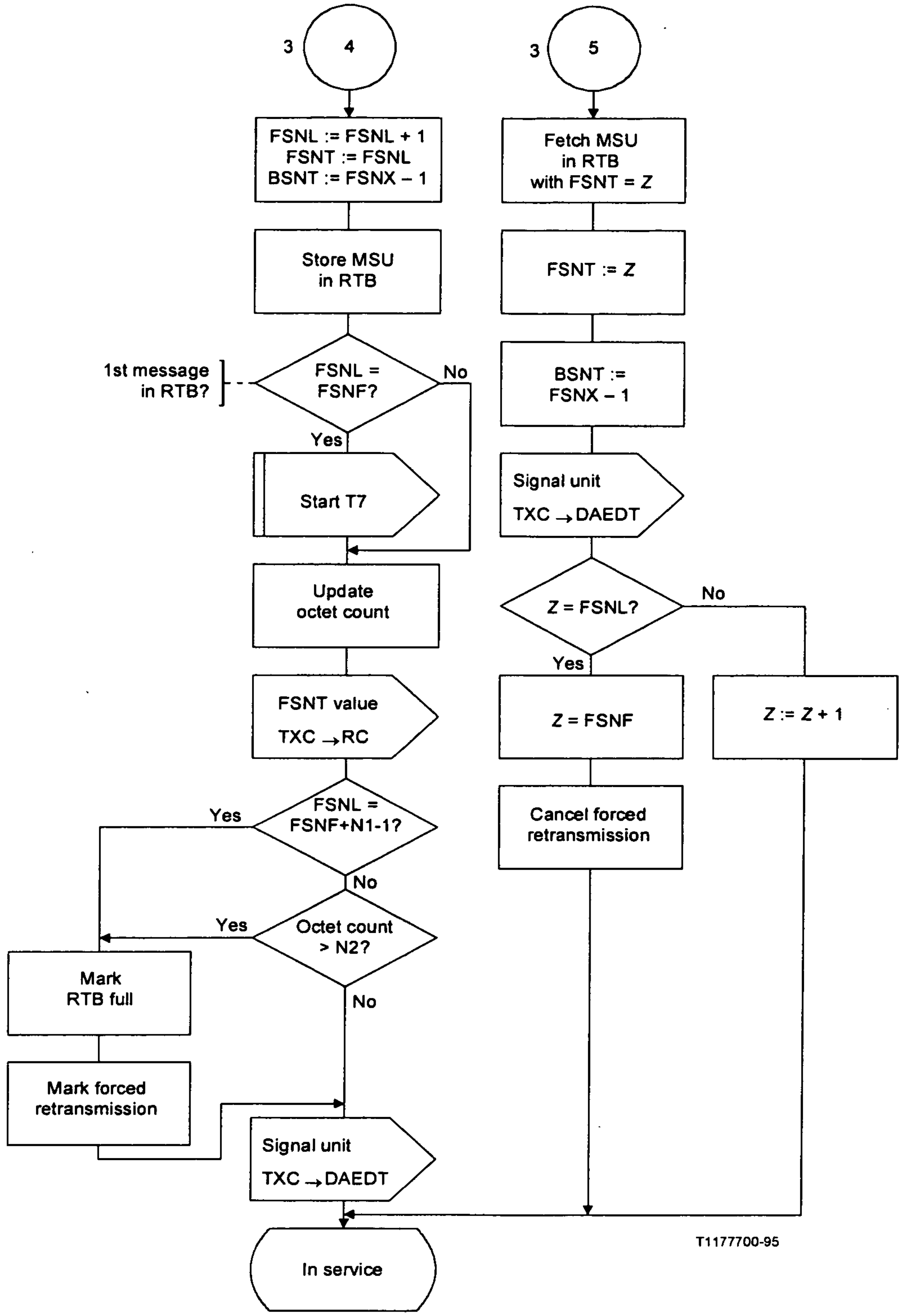
Figure 15/Q.703 (sheet 2 of 7) – Preventive cyclic retransmission – Transmission control



NOTE – See the abbreviations and timers used in this Figure in 12.2.

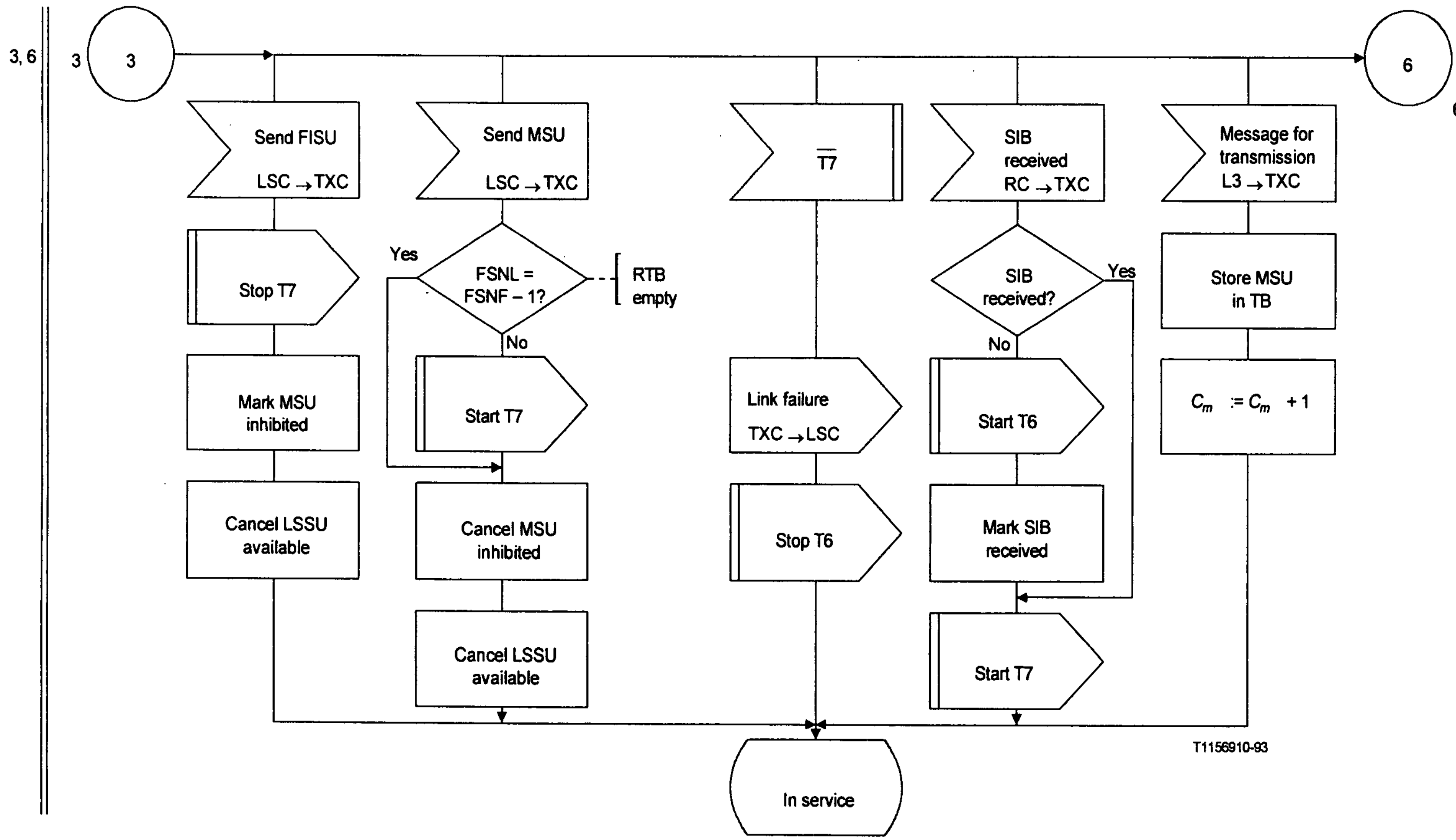
Figure 15/Q.703 (sheet 3 of 7) – Preventive cyclic retransmission – Transmission control

4, 5



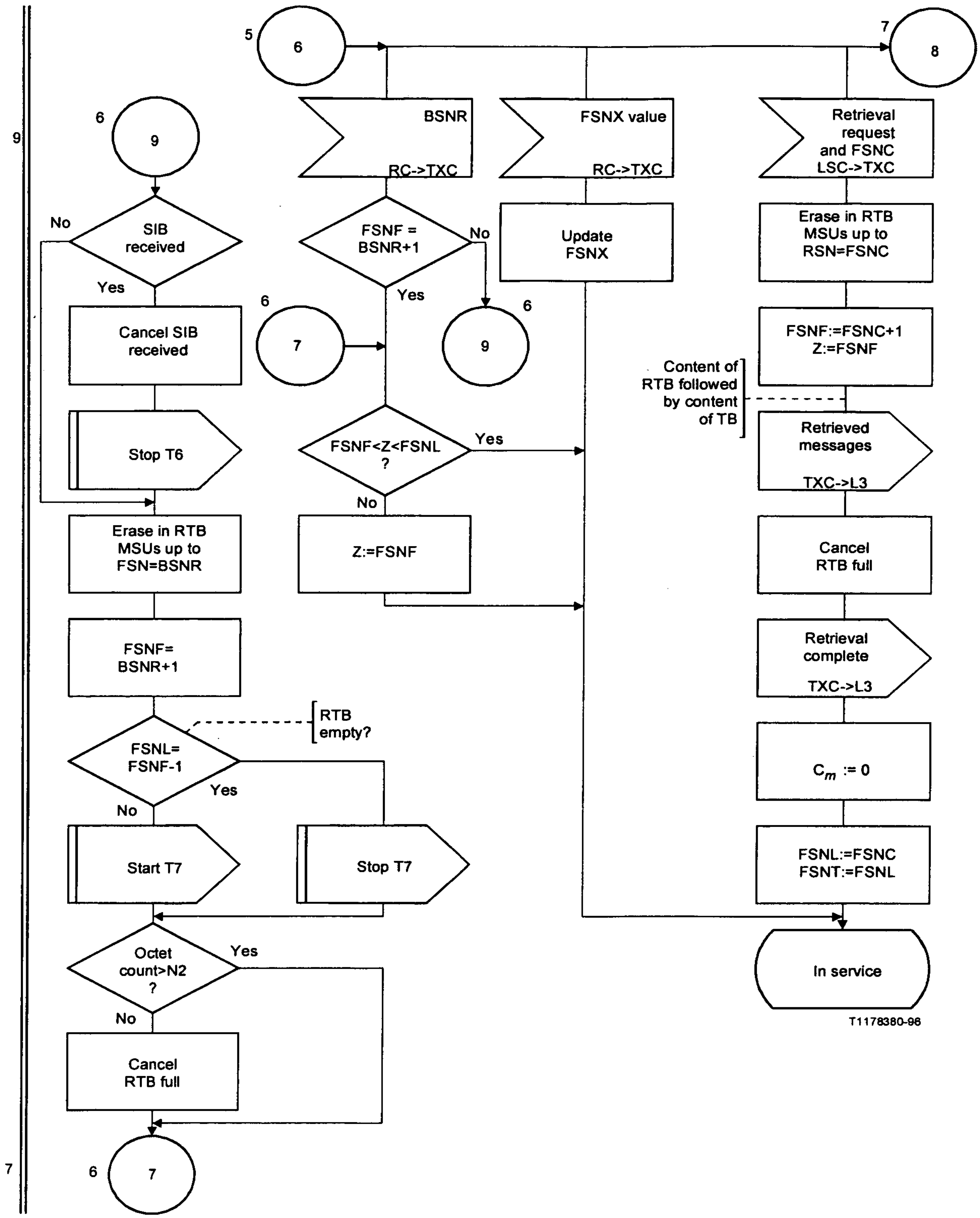
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 15/Q.703 (sheet 4 of 7) – Preventive cyclic retransmission – Transmission control



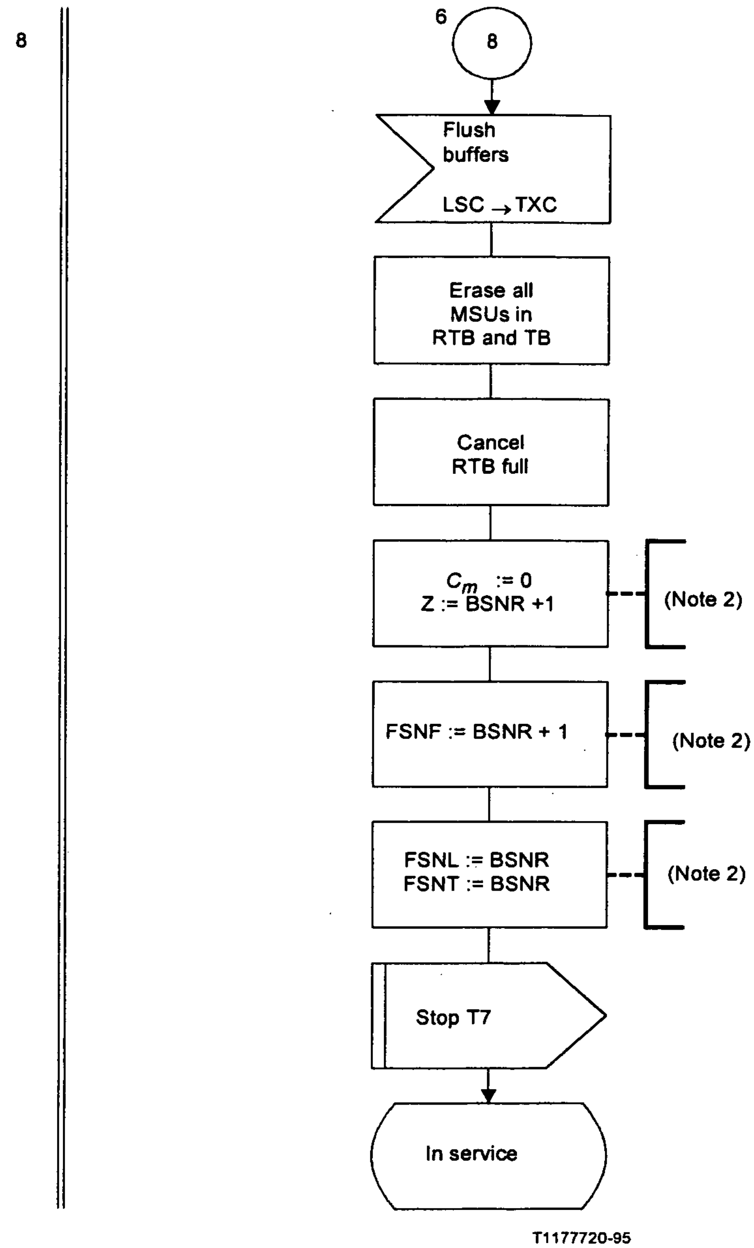
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 15/Q.703 (sheet 5 of 7) – Preventive cyclic retransmission – Transmission control



NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 15/Q.703 (sheet 6 of 7) – Preventive cyclic retransmission – Transmission control

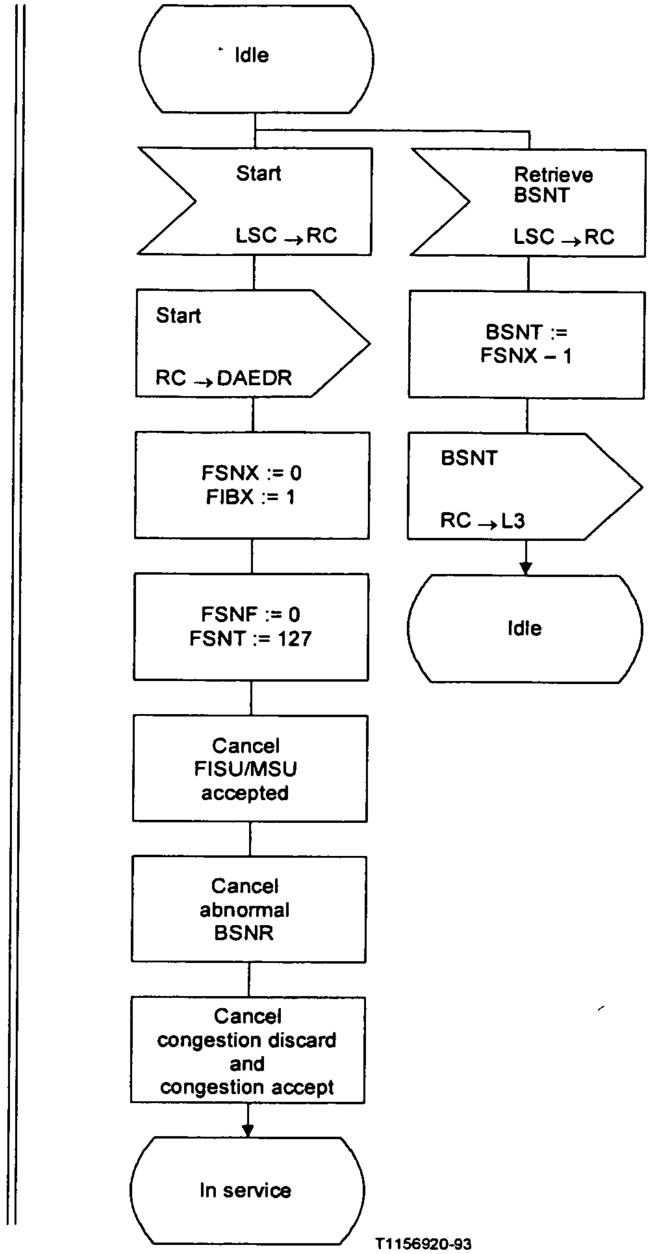


NOTES

1 – See the abbreviations and timers used in this Figure in 12.2.

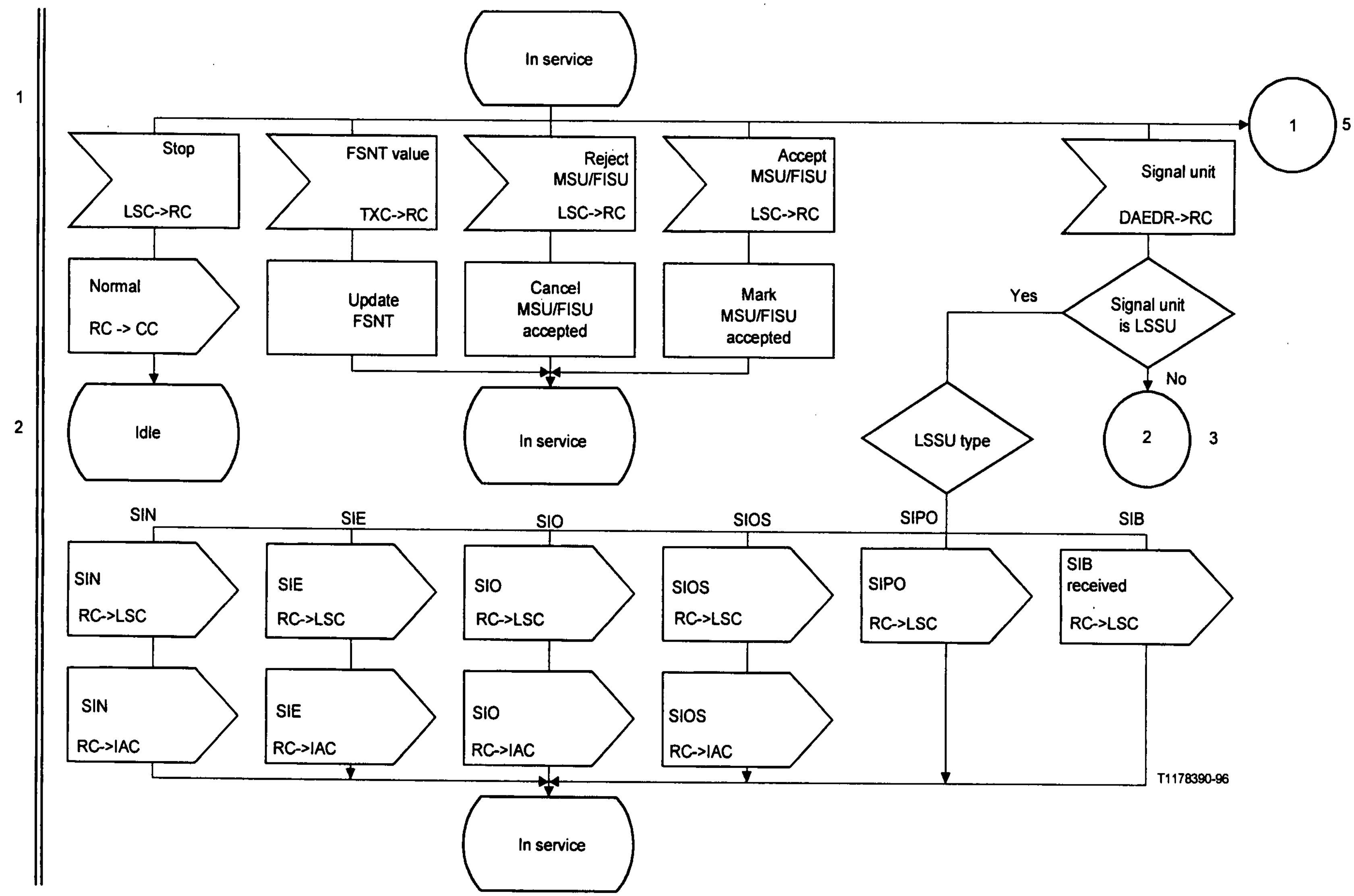
2 – The BSNR is from the first MSU/FISU terminating the remote processor outage state.

Figure 15/Q.703 (sheet 7 of 7) – Preventive cyclic retransmission – Transmission control



NOTE – See the abbreviations and timers used in this Figure in 12.2.

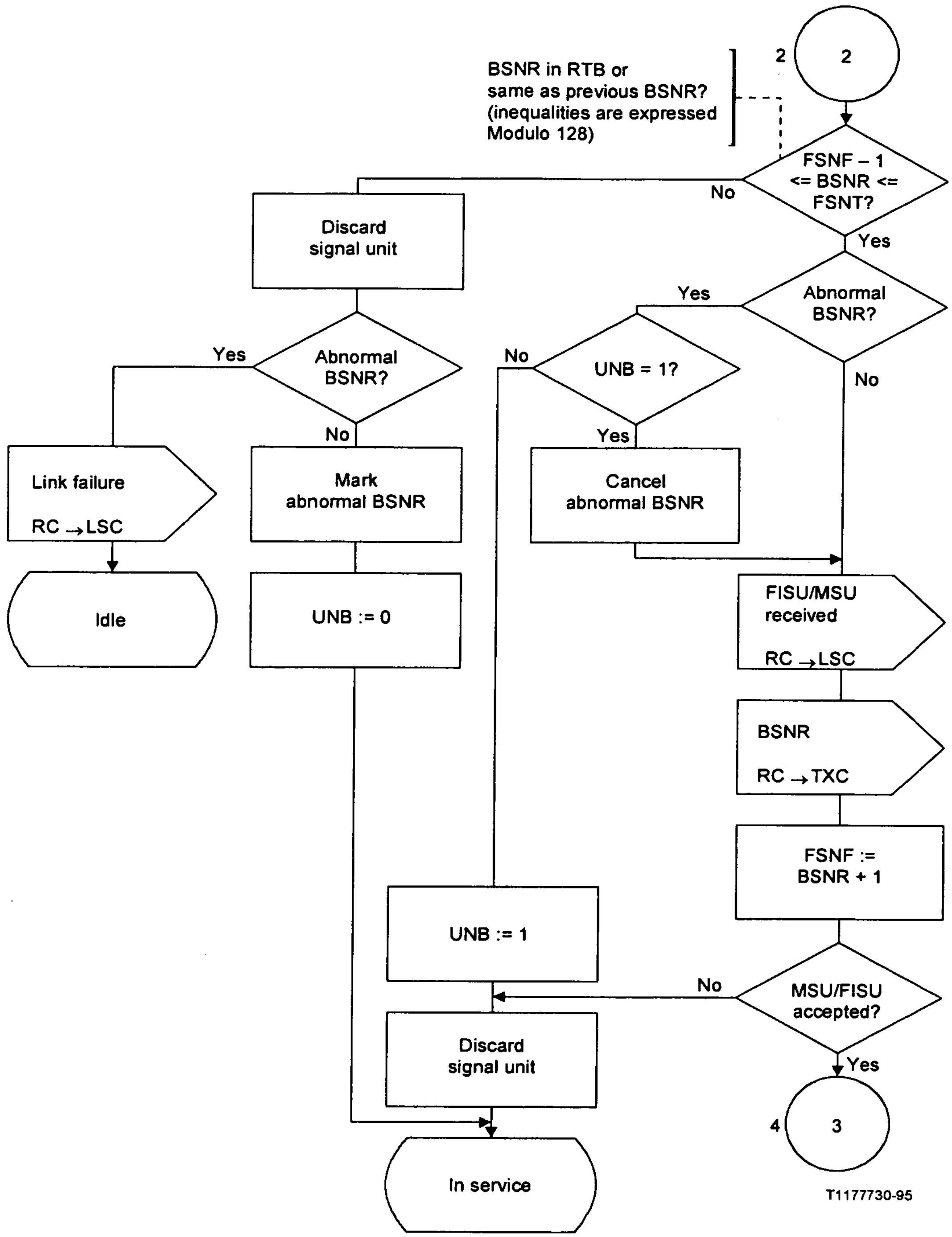
Figure 16/Q.703 (sheet 1 of 6) – Preventive cyclic retransmission – Reception control



NOTE - See the abbreviations and timers used in this Figure in 12.2

Figure 16/Q.703 (sheet 2 of 6) – Preventive cyclic retransmission – Reception control

2

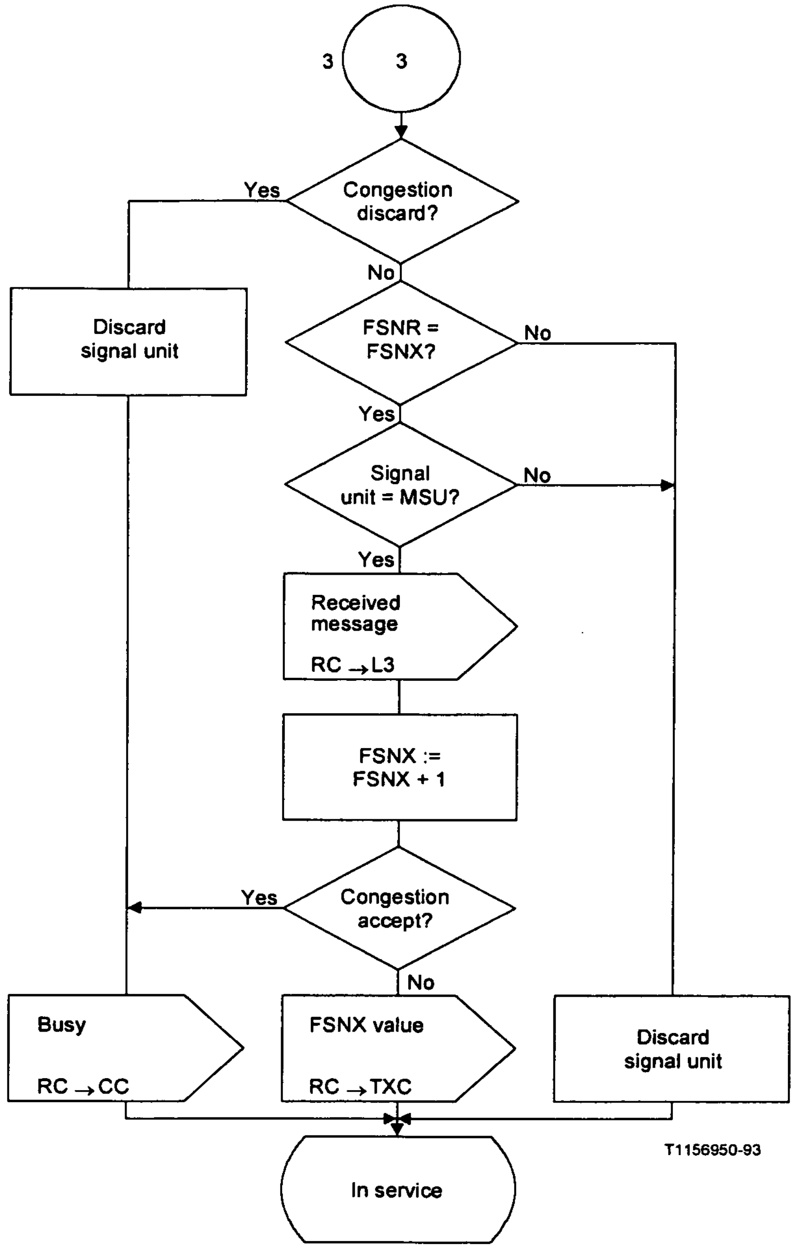


3

NOTE – See the abbreviations and timers used in this Figure in 12.2.

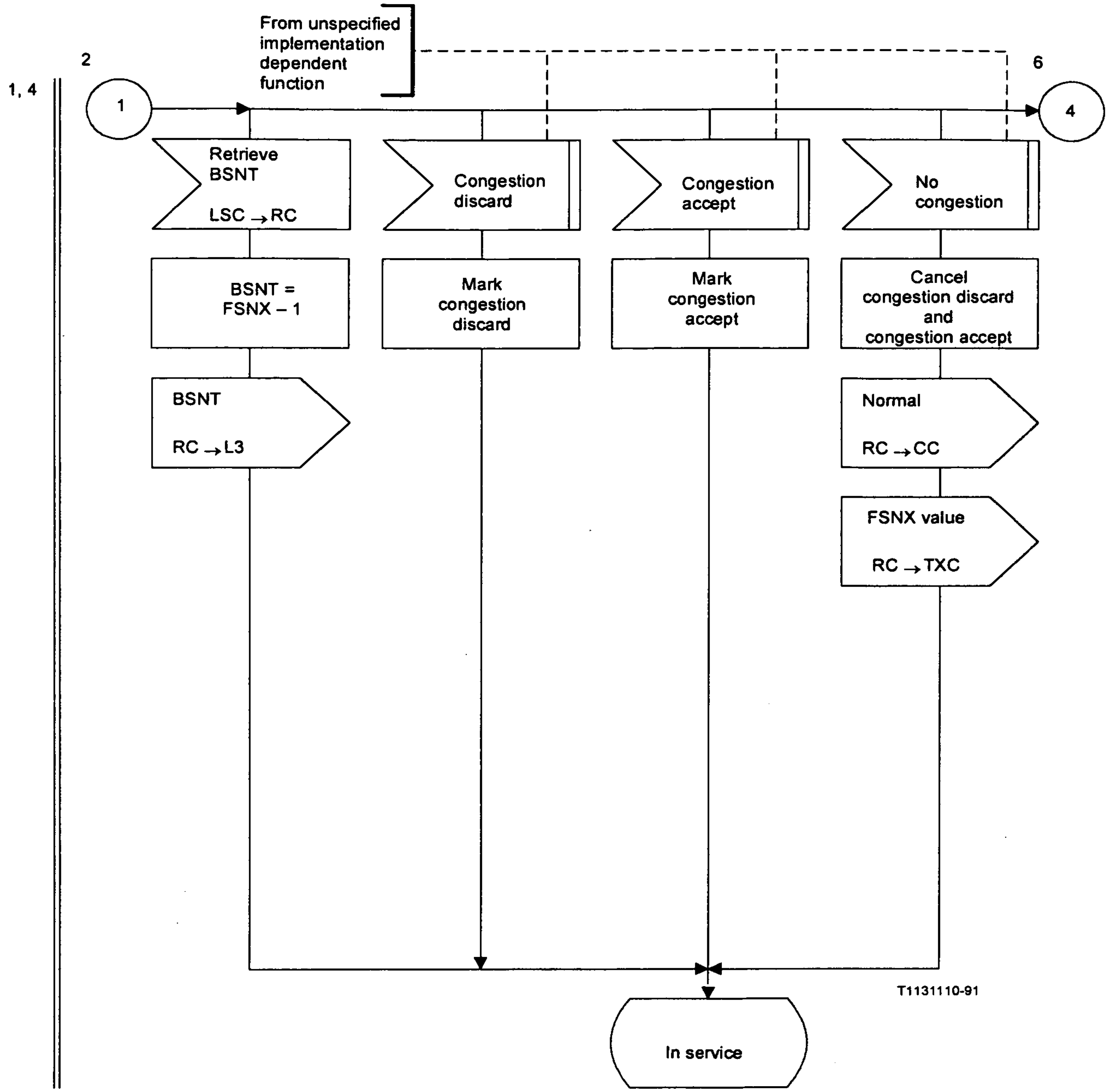
Figure 16/Q.703 (sheet 3 of 6) – Preventive cyclic retransmission – Reception control

3



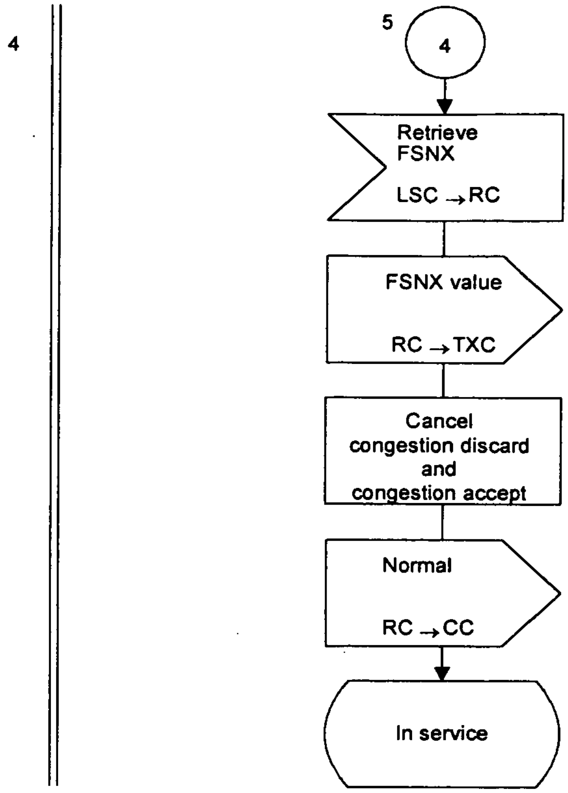
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 16/Q.703 (sheet 4 of 6) – Preventive cyclic retransmission – Reception control



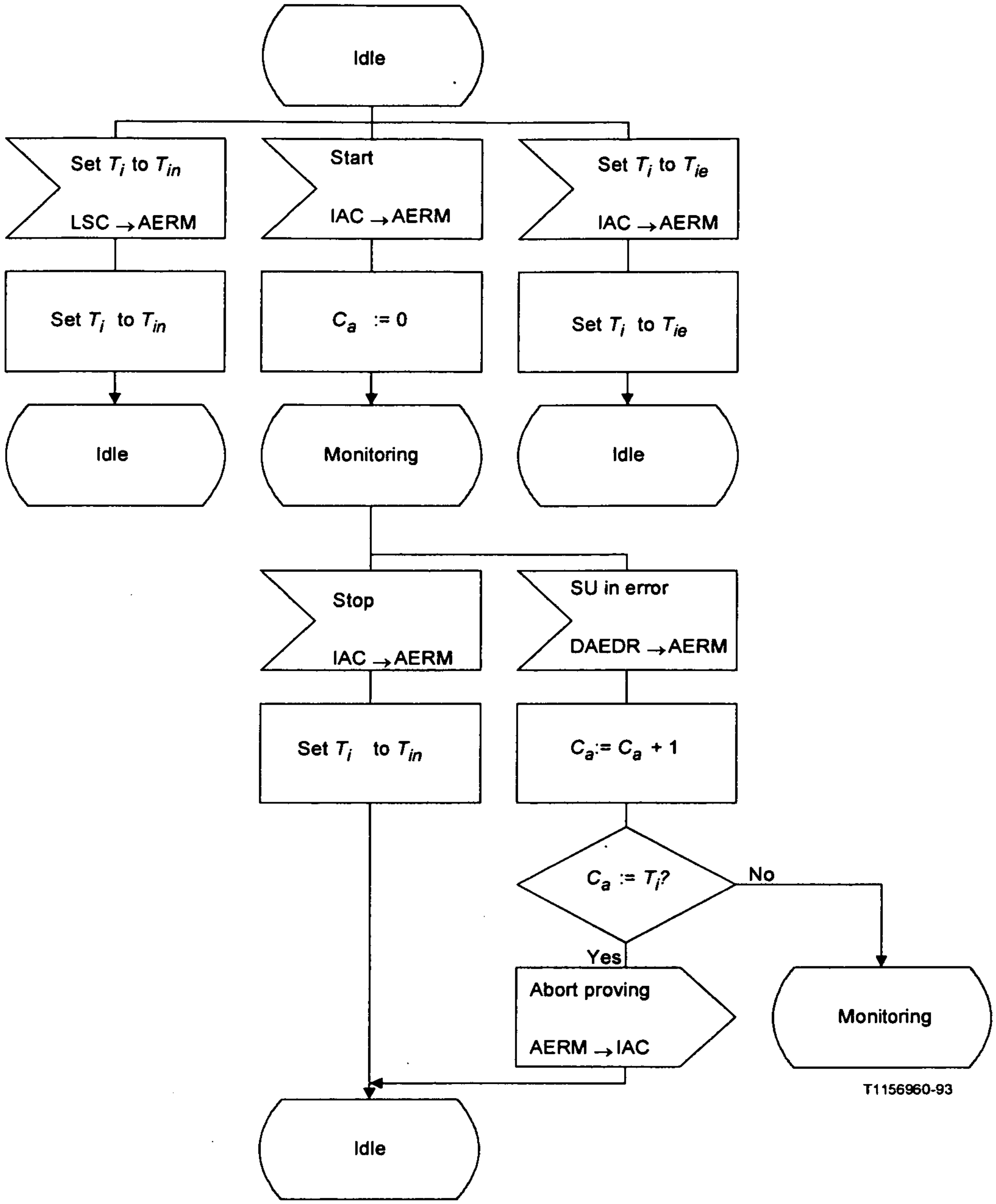
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 16/Q.703 (sheet 5 of 6) – Preventive cyclic retransmission – Reception control



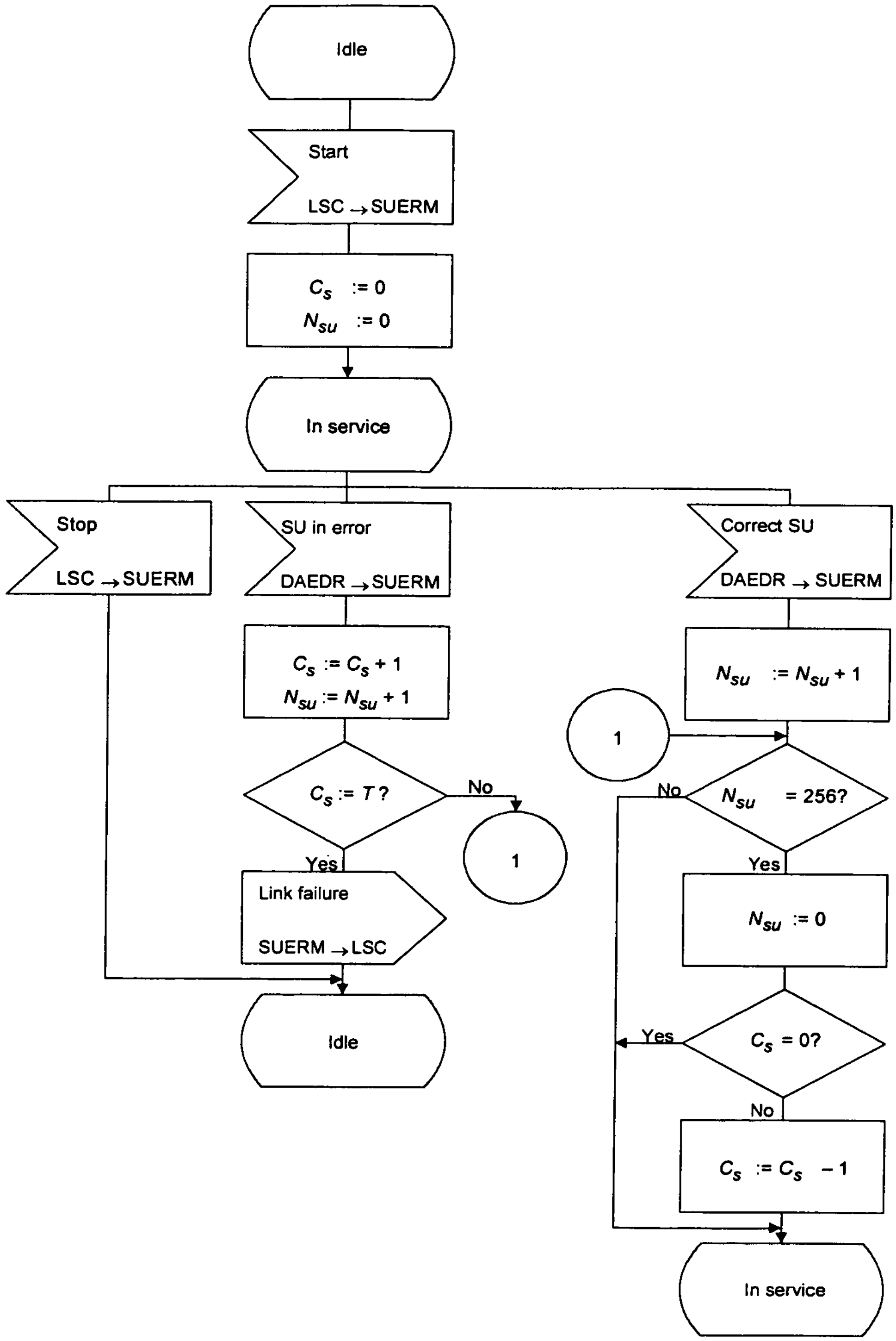
NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 16/Q.703 (sheet 6 of 6) – Preventive cyclic retransmission – Reception control



NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 17/Q.703 – Alignment error rate monitor

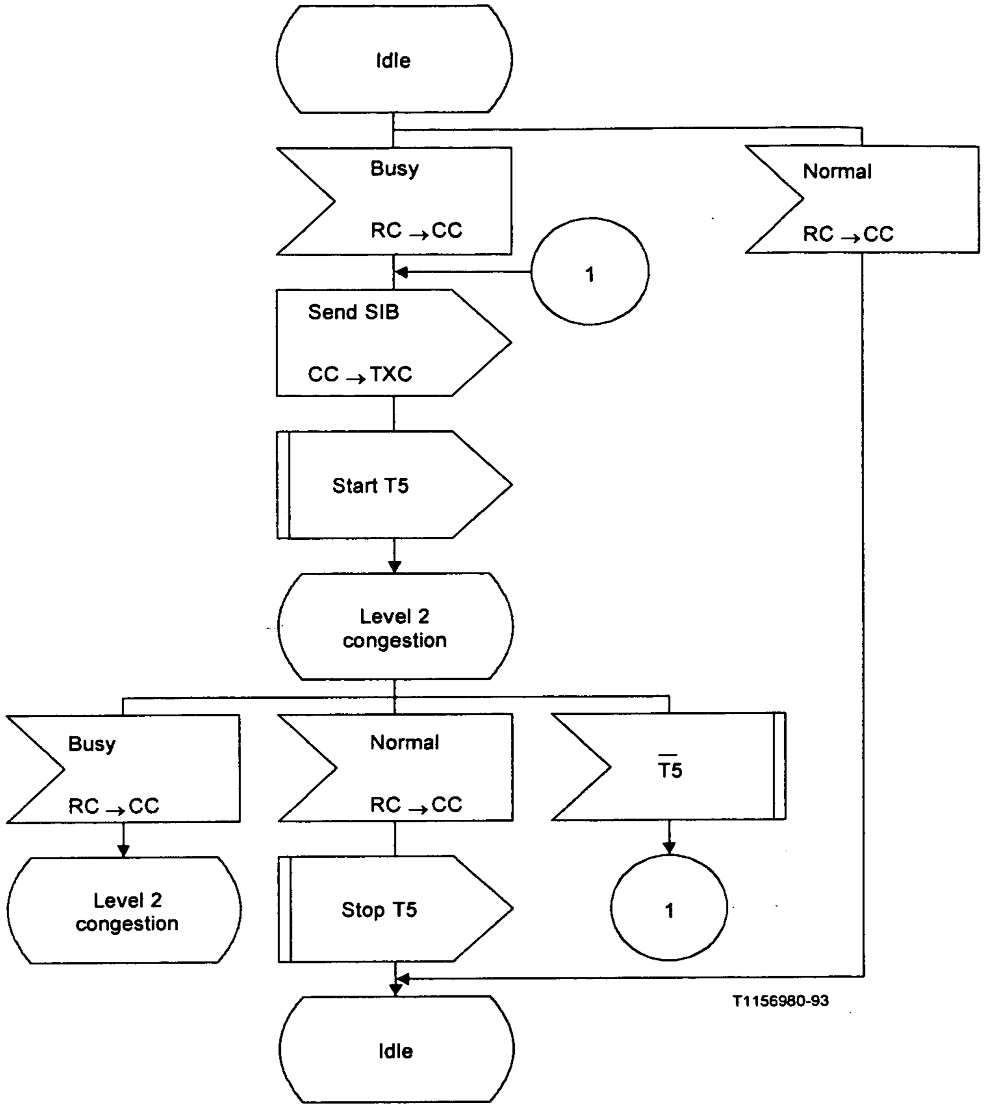


1

1

NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 18/Q.703 – Signal unit error rate monitor



NOTE – See the abbreviations and timers used in this Figure in 12.2.

Figure 19/Q.703 – Congestion control

ANNEX A

Additions for a national option for high speed signalling links

A.1 Introduction

This Annex provides the additions to this Recommendation to support enhanced MTP Level 2 functions and procedures that are suitable for the operation and control of signalling links at data rates of 1.5 and 2.0 Mbit/s as a national option.

A.1.1 Procedures for 1.5 and 2.0 Mbit/s data rate signalling links

The additions to this Recommendation presented below will use the numbering sequences, after the A., that correspond to the numbering in this Recommendation to facilitate the identification of those procedures.

A.2.3.3 Length indicator

The procedure for the length indicator remains as specified in 2.3.3/Q.703. If the extended sequence number format is used, then the length indicator will encode the length of the message, ranging from 0 to 273 octets.

A.2.3.5 Sequence numbering for 1.5 and 2.0 Mbit/s data rates

The existing Level 2 MTP format is used. Depending on the delay characteristics, the network operator may decide to use extended sequence numbers (12 bits). In this case, the forward sequence number and backward sequence number are in binary code from a cyclic sequence from 0 to 4095[6]. (See clause 5/Q.703 and clause 6/Q.703.)

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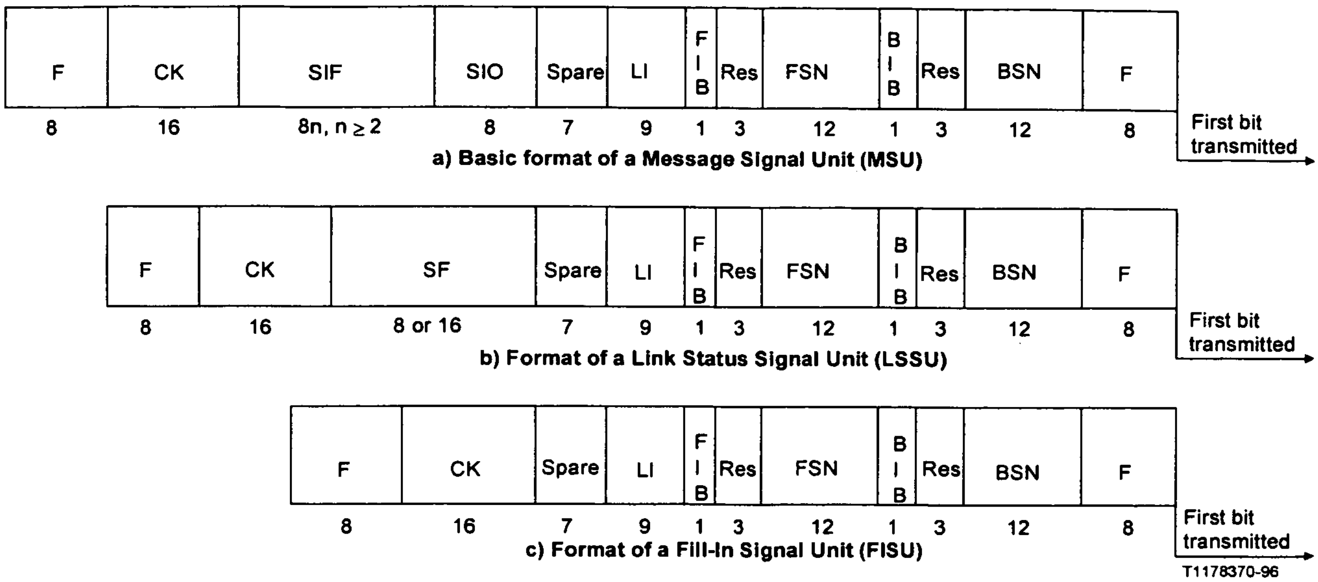
[6] If extended sequence numbers are used, then the FSN value will not fit into the FSN field conveyed in MTP3 Changeover Order and Changeover Acknowledgement message types, therefore the MTP used should have the capabilities of Recommendation Q.2210.



BIB	Backward Indicator Bit
BSN	Backward Sequence Number
CK	Check bits
F	Flag
FIB	Forward Indicator Bit
FSN	Forward Sequence Number
LI	Length Indicator
n	Number of octets in the SIF
SF	Status Field
SIF	Signalling Information Field
SIO	Service Information Octet

Figure A.1/Q.703 – Signal unit formats for 1.5 and 2.0 Mbit/s rates

(extended sequence numbers)

A.4 Acceptance procedure

A.4.1 Acceptance of alignment

The errored interval monitor is applied instead of the signal unit error rate monitor.

A.4.1.2 The octet counting mode is not used when a flag is lost.

A.4.1.3 If the extended sequence number format is used, then the check for the correct signal unit length is increased by 3 octets.

A.10.1 General

When link data rates of 1.5 Mbit/s and 2.0 Mbit/s are used, the errored interval monitor is applied instead of the signal unit error rate monitor.

A.10.2 Errored interval monitor for 1.5 Mbit/s and 2.0 Mbit/s links

A.10.2.1 The errored interval monitor has as its function the estimation of signalling link fault conditions by monitoring errors over a prescribed interval to model the queue build up on the transmitting end. An interval is errored if one or more signal units are rejected by the acceptance procedure (see clause 4/Q.703), or a flag is lost. The four parameters that determine the errored interval monitor are:

- the number of intervals where signal units have been received in error that will cause an error rate high indication to level 3, T_E (intervals);
- the constant U_E for incrementing the counter;
- the constant D_E for decrementing the counter; and
- timer T8, the interval for monitoring errors.

A.10.2.2 The errored interval monitor is implemented in the form of an up and down counter decremented at a fixed rate D_E for every interval where no signal unit is errored, but not below zero, and incremented at a fixed rate U_E for every interval where one or more signal unit errors are detected by the signal unit acceptance procedure (see 4.1.3) or where no flag is received but not above threshold T_E. An excessive error rate shall be indicated whenever the threshold T_E is reached.

A.10.2.3 The octet counting mode, which provides an estimate of a signal unit, is not used for the errored interval monitor, because this procedure is not based on an accounting of individual errors.

A.10.2.4 When the link is brought into service, the monitor count shall start from zero.

A.10.2.5 The values for the four parameters of the errored interval monitor are given in Table A.1.

Table A.1/Q.703 – Values for the errored interval parameters

Parameter	Definition	1.5 Mbit/s links	2.0 Mbit/s links
T_E	Threshold count	577.169	793.544
U_E	Constant for upcount	144 292	198 384
D_E	Constant for downcount	9308	11 328
T8	Monitoring interval (msec)	100 msec	100 msec

A.10.3 Alignment error rate monitor

The procedure in 10.3/Q.703 is applicable, except that the octet counting mode is not used.

A.12.3 Timers

The timer values that are changed for these high speed signalling links are as follows:

T1		Timer "alignment ready"
	T1 = 300 s (range 25 - 350 s)	Bit rate of 1.5 and 2.0 Mbit/s
T4		Proving period timer = 2^{16} or 2^{12} octet transmission time
	T4*n* = 30 s (range 3 - 70 s)	Normal proving period at 1.5 and 2.0 Mbit/s
	T4*e* = 400 - 600 ms	Emergency proving period at 1.5 and 2.0 Mbit/s

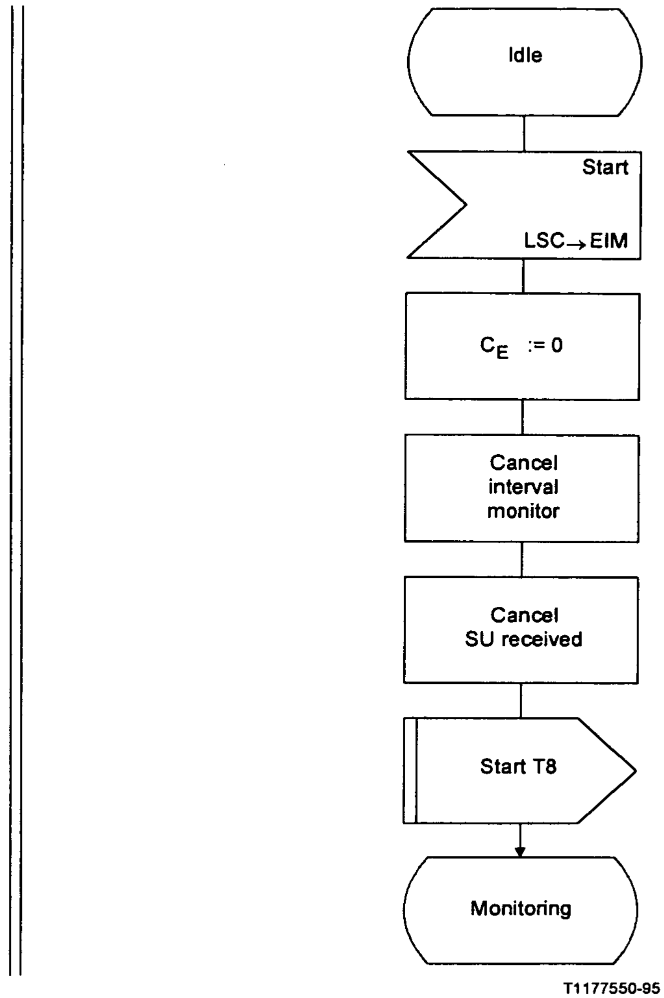


Figure A.2/Q.703 (sheet 1 of 2) – Errored interval monitor for 1.5 and 2.0 Mbit/s links

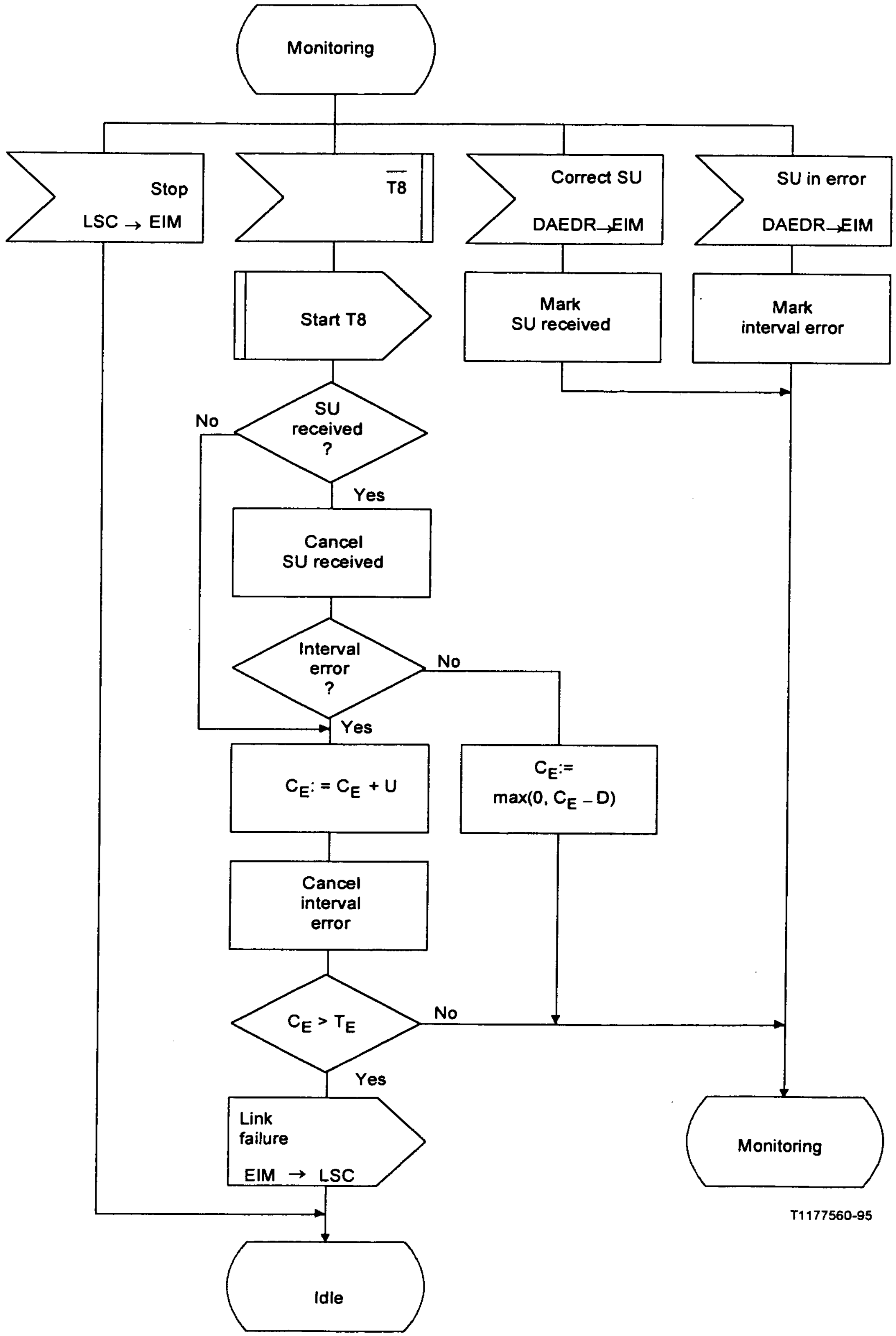


Figure A.2/Q.703 (sheet 2 of 2) – Errored interval monitor for 1.5 and 2.0 Mbit/s links

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